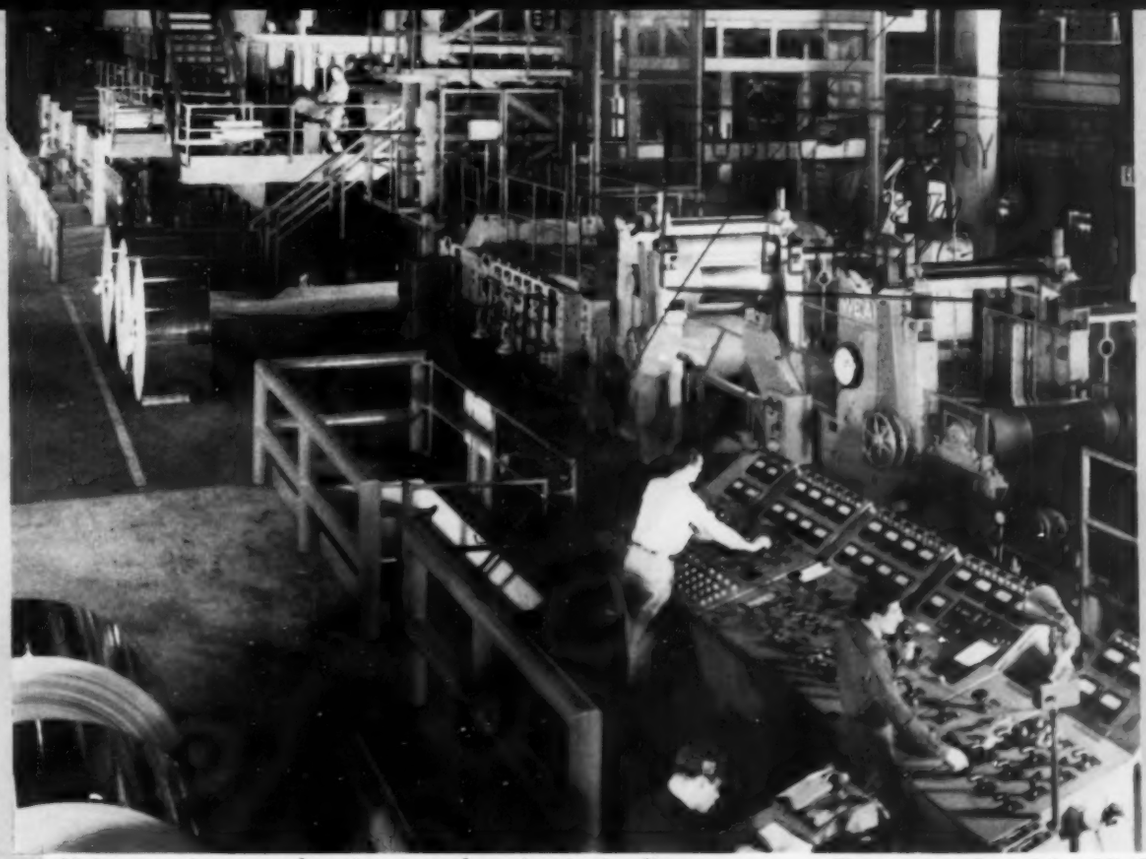
Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JULY, 1957 TECHNOLOGY DEPT.

Faster, better tinplate production through WEAN creative engineering



Main operating control station controls entire tinning line. Photo courtesy Jones & Laughlin Steel Corp.

WEAN

• 75% of all electrolytic tin plate is produced on Wean engineered lines . . . and for a very good reason. Wean, a pioneer in continuous coating lines, has played a major role in bringing tin plate production equipment to its present high degree of efficiency.

Some time ago, for example, Wean adapted automation to tin plate production—enabling lines to produce continuously—establishing records both for speed of production and quality of product; in short, enabling tin plate producers to keep abreast of modern industrial demands.

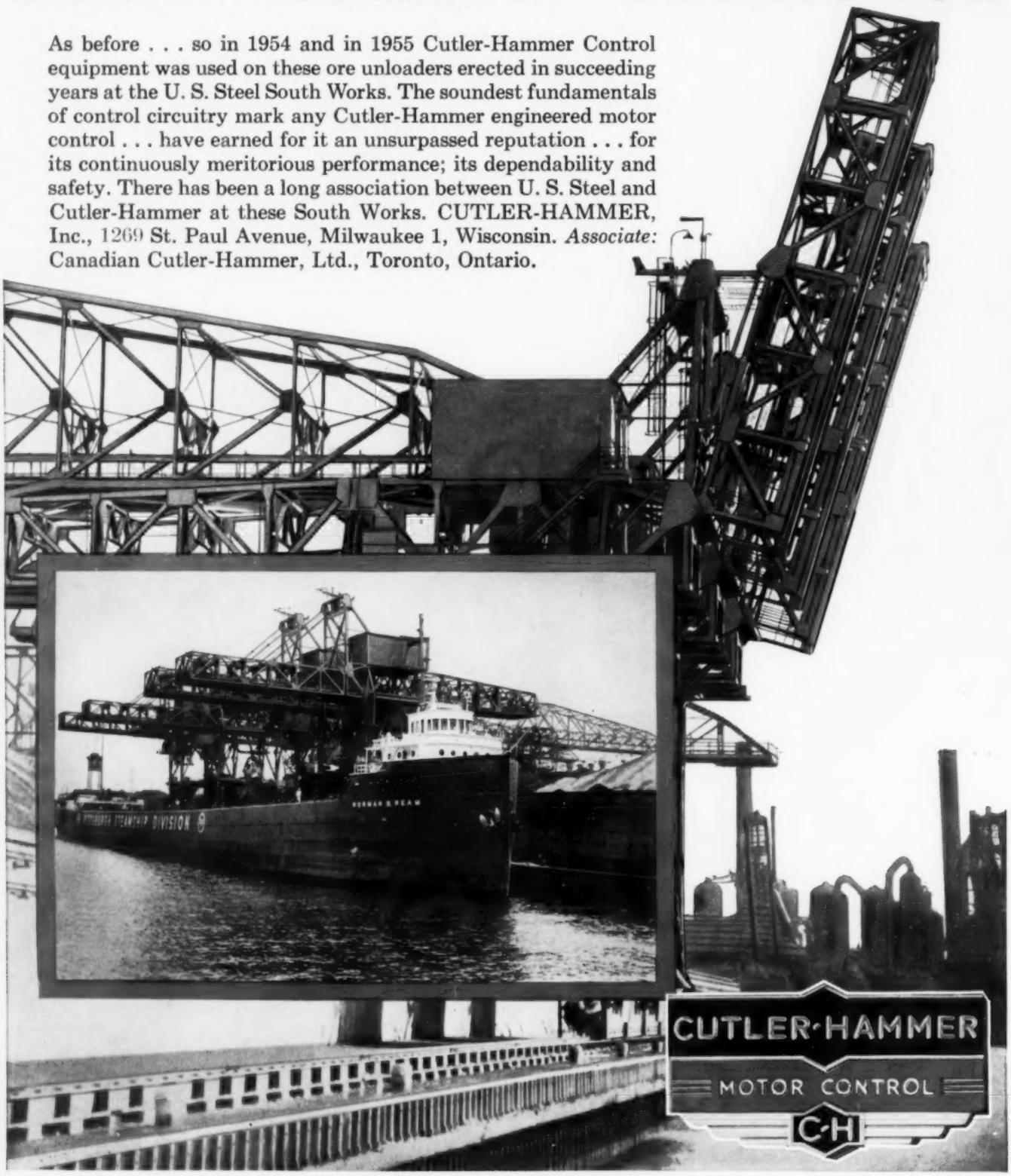
So, if you're looking for tin plate facilities to meet today's exacting requirements . . . look to Wean, world's foremost designer of electrolytic cleaning and tin plate equipment.

339A

THE WEAN ENGINEERING COMPANY, INC. WARREN, O.

SEVEN GIANTS
at USS South Works
Cutler-Hammer Controlled

As before . . . so in 1954 and in 1955 Cutler-Hammer Control equipment was used on these ore unloaders erected in succeeding years at the U. S. Steel South Works. The soundest fundamentals of control circuitry mark any Cutler-Hammer engineered motor control . . . have earned for it an unsurpassed reputation . . . for its continuously meritorious performance; its dependability and safety. There has been a long association between U. S. Steel and Cutler-Hammer at these South Works. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.



LOOK TO CUTLER-HAMMER MILL EXPERIENCE...AS BROAD AS IT IS LONG

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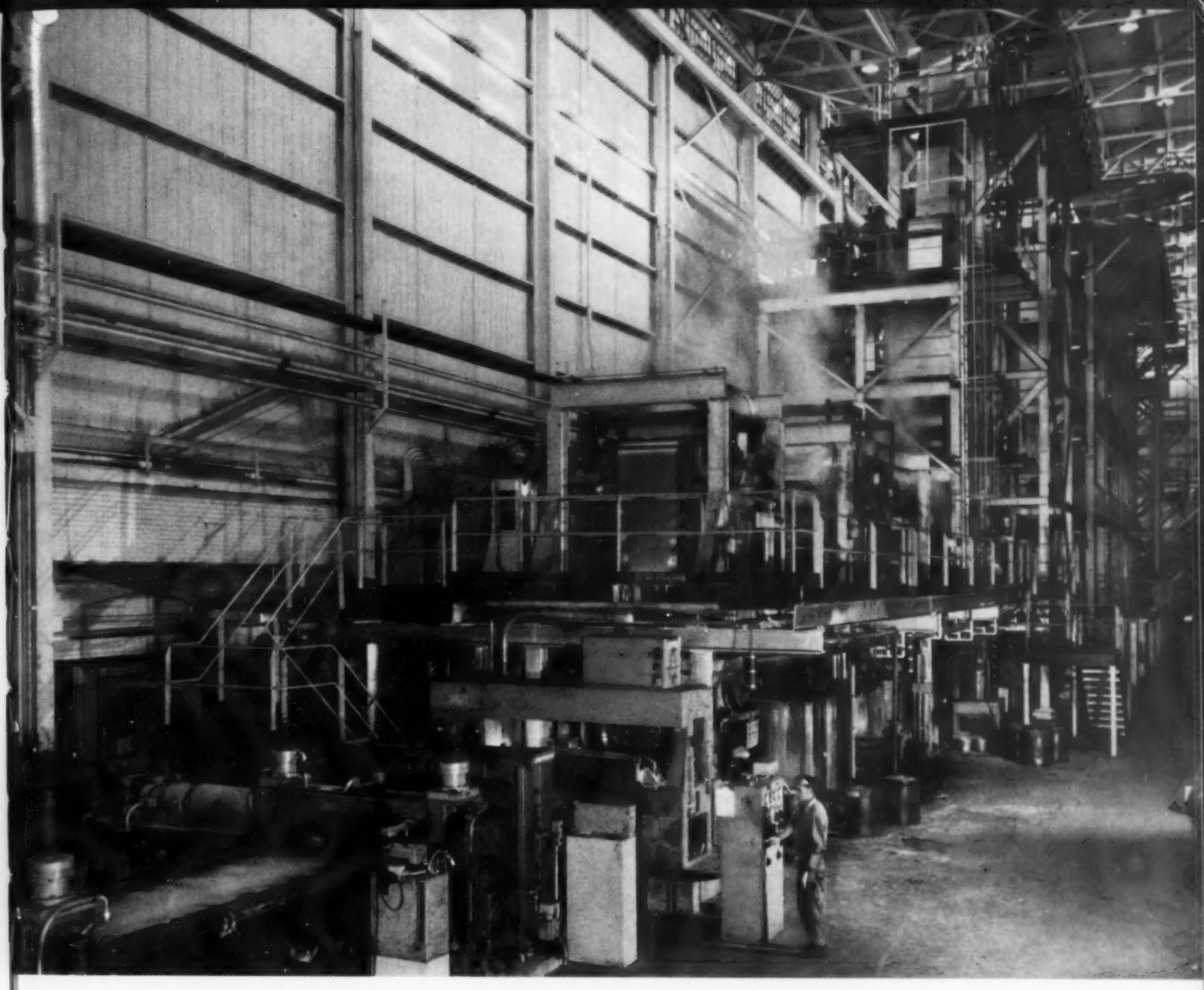

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• This is one of several Continuous Annealing Lines designed and built by Aetna-Standard. The line processes 48" wide strip maximum at 1000 feet a minute at Dominion Foundries and Steel, Limited, Hamilton, Ontario, Canada. This line has been designed so that the Annealing Furnace can be bypassed and strip run through for cleaning only.

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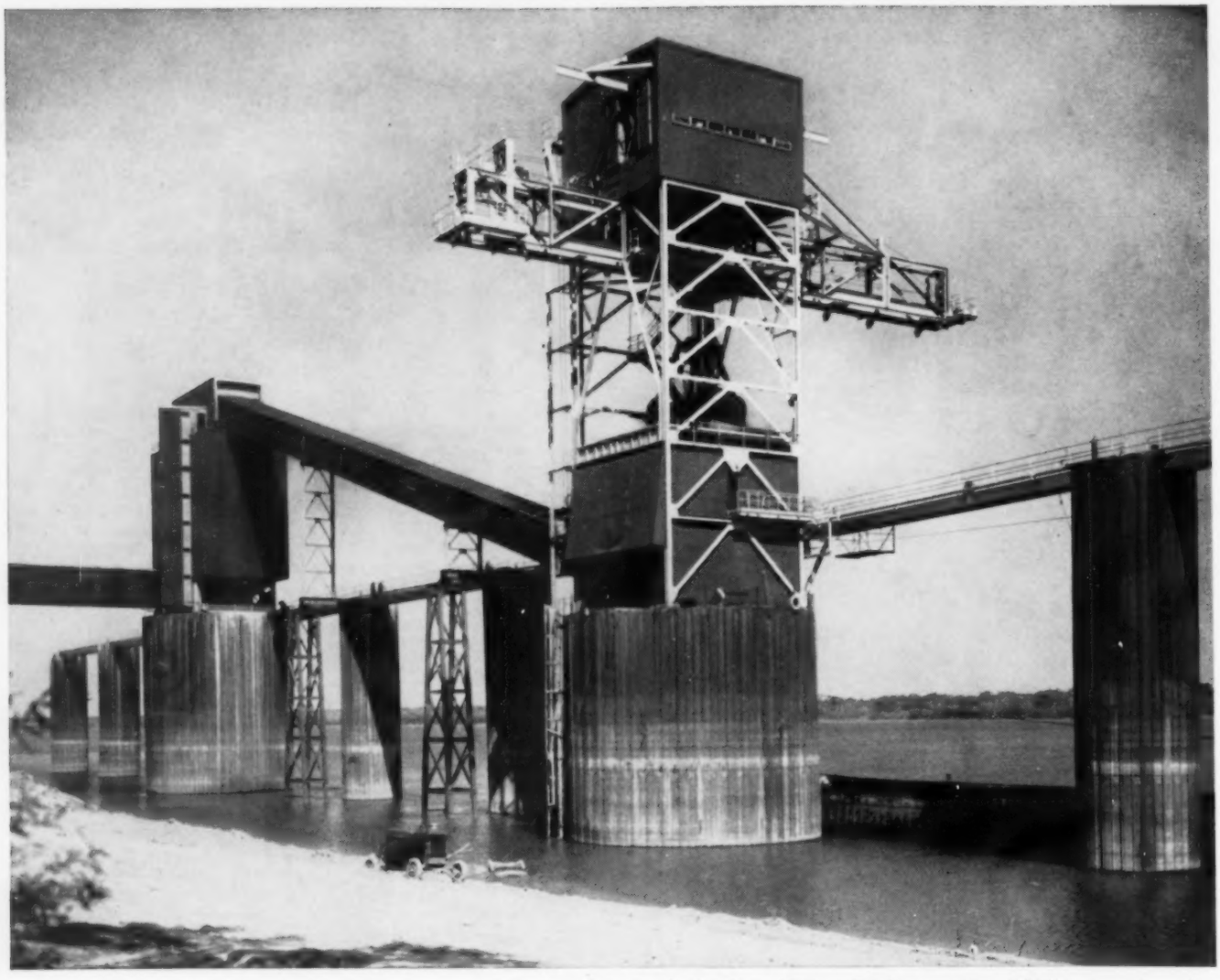

9-ton coal unloader, with free digging capacity of 850 tons per hour, has an average operating lift of 75 feet and travel distance of 40 feet.

Barge unloading?...WE DO THE COMPLETE JOB— unloading tower, dock and all auxiliaries

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Dravo heavy materials handling equipment is at work in power plants, steel mills, port docks and other materials transfer points. You can learn about Dravo's complete line of trolleys, bridges, towers and other related equipment by writing for Bulletin #225. Better still, let us arrange for your visit to actual installations. Simply call us at Pittsburgh, Spalding 1-1200, or write DRAVO CORPORATION, PITTSBURGH 25, PENNSYLVANIA.

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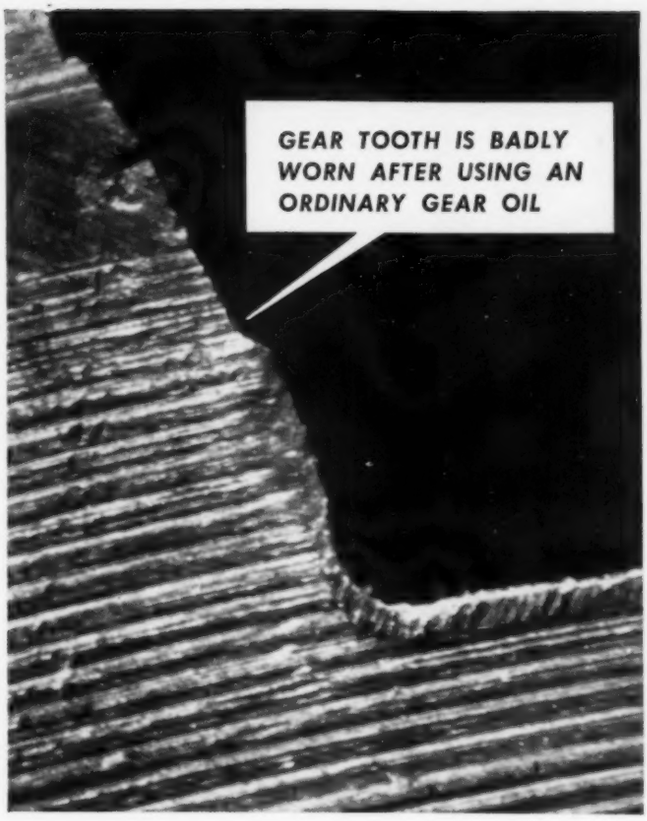

COMPARATIVE TESTS on identical new worm gears demonstrate superiority of Sunep Gear Lubricant. Gear on left, using a compounded cylinder oil, shows excessive wear at 70 hours. Gear on right, protected by Sunep, shows minimum wear after running over 200 hours!

HERE'S PROOF SUNEP GEAR LUBRICANTS MINIMIZE WEAR

Sunep Gear Lubricants cut power losses... protect against overloads ...lengthen gear life...reduce maintenance costs and replacements.

During recent tests gear units protected by Sunep Gear Lubricant showed an absolute minimum of wear when run at normal rated capacity. There was no indication of scoring or wear even when run at overloads up to 118%! Power consumption was reduced up to 25%. Damage from shock loads was nil.

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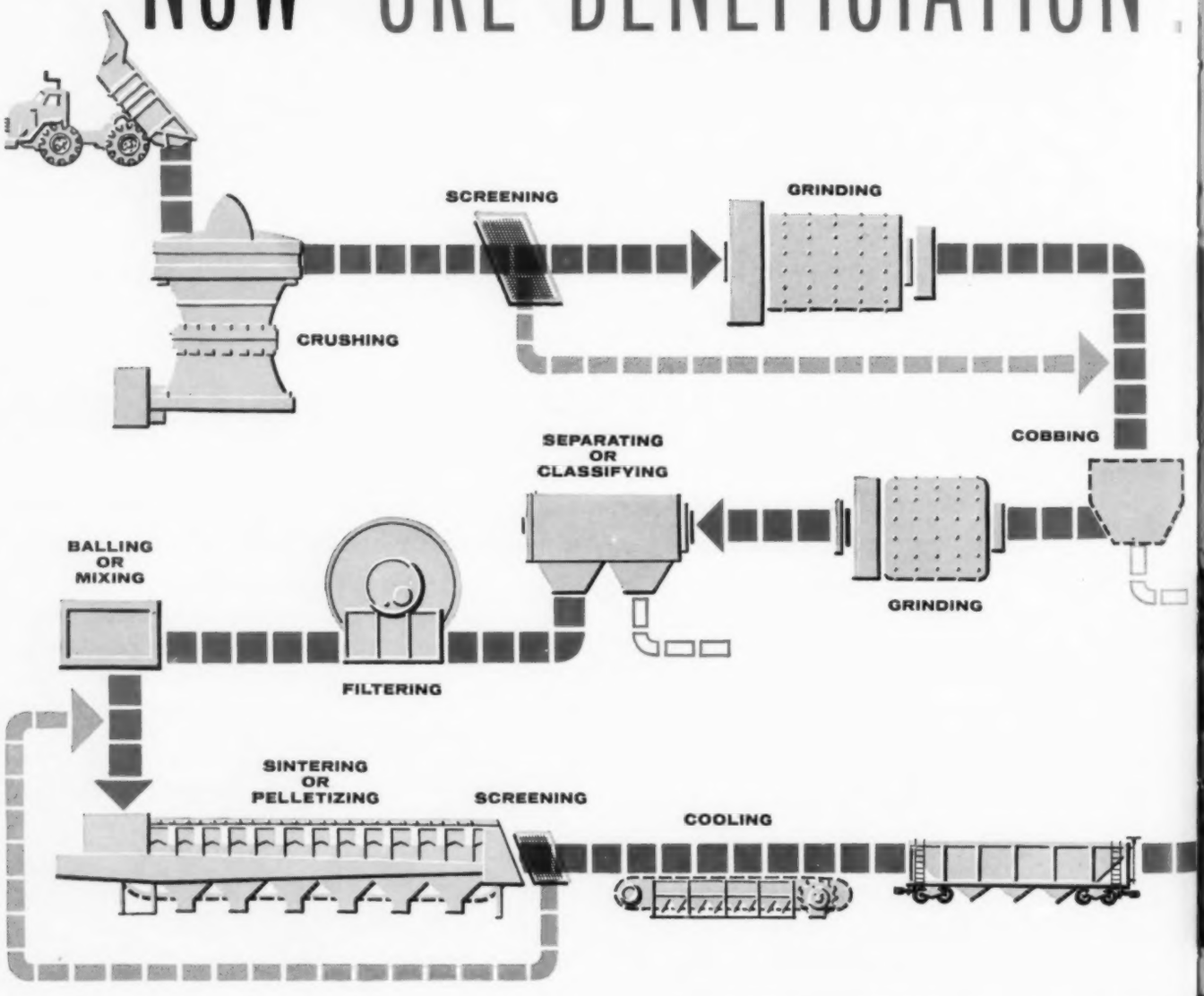

In every phase of ore beneficiation symbolized in this drawing . . . in crushing, conveying, grinding, separating, sintering . . . Koppers experience can help you.

. by Koppers

COMPLETE engineering and construction of all types of ore beneficiation plants is now available from the Freyn Department of Koppers. An Ore Beneficiation Section, staffed by experienced engineers, now offers a wide range of services to ore producers. This Section is backed by Koppers wide experience in steel plant construction, materials handling, and chemical engineering.

KOPPERS KNOWS THE STEEL BUSINESS

For 50 years Koppers has been designing, engineering and constructing almost every type of facility used in making steel—from coke ovens to completely integrated steel plants. Sintering—often a vital part of the ore beneficiation process—has been a specialty of Koppers American Ore Reclamation Section since 1911. And the Freyn Department of Koppers has done work in all phases of steelmaking. This experience can help you in the planning and building of an ore beneficiation plant.

KOPPERS KNOWS MATERIALS HANDLING

Koppers has wide experience in the engineering and installation of large materials handling systems—including ore-handling facilities which are so important in the operation of a beneficiation plant.

KOPPERS KNOWS CHEMICAL ENGINEERING

Chemical engineering is assuming growing importance in the beneficiation of low-grade iron ores, and especially in non-ferrous ores. Koppers has many years of chemical engineering experience.

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Let Koppers engineer and build your ore beneficiation plant. You will gain from Koppers accumulated knowledge of the equipment and operations involved in ore beneficiation. You will gain from Koppers knowledge of the steel business and its problems. You will gain from Koppers ability to handle *all phases* of the job competently—from initial planning and design to the construction and final operation of the plant.

Write for further information. A Koppers specialist in ore beneficiation will call on you. Koppers Company, Inc., Engineering and Construction Division, Freyn Department, Pittsburgh 19, Pennsylvania.

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TODAY'S MOST WIDELY ACCEPTED BELT IDLER

Here's what men who know idlers have to say

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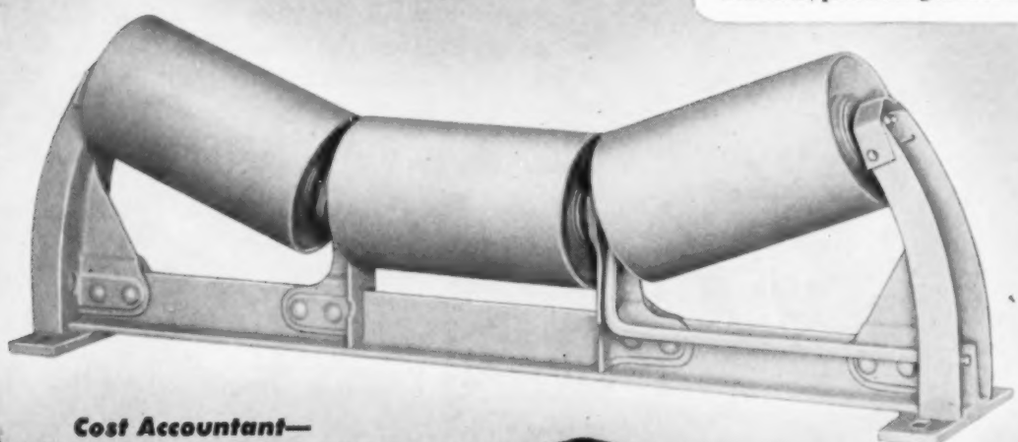
"Service records of the Link-Belt Series 100 belt conveyor idler show that there's no more durable belt conveyor idler in the capacity range. It's a 'work horse'—gives economical service under hard duty, conveying all but the heaviest and coarsest materials."

Engineer—

"Look at these design features. Self-contained, concentric rolls with bearings fully enclosed and protected . . . strong heavy ribbed brackets and sturdy rigid frames maintain accurate roll alignment—won't spread under load . . . hex nuts that lock rolls in brackets, preventing shaft rotation."



Cost Accountant—

"All costs considered—installation, operation and maintenance. You won't find a better buy in belt conveyor idlers than the Link-Belt Series 100. Its free-rolling action requires less power . . . reduces wear on operating parts and belt . . . cuts replacements."

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RUGGED . . . free-rolling . . . dirt- and dust-proof—the Link-Belt Series 100 belt conveyor idler combines these and other features for low-cost, dependable materials handling under severe, continuous service conditions. What's more, you have a wide choice of types for any requirement—whether you handle coal, sand, gravel or iron ore . . . sticky or free-flowing materials.

Sturdy rolls of the Series 100 are accurately machined for concentricity—welded for added strength and to keep out dirt and moisture. Smooth, round surfaces and edges prevent belt damage. As for dependability of its roller bearings—Link-Belt has *never* known a bearing failure due to overloading a Series 100 idler. Equally important, strong malleable iron brackets and sturdy, rigid frames maintain accurate roll alignment.

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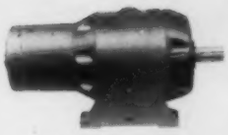
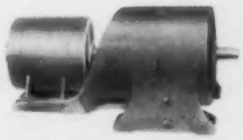
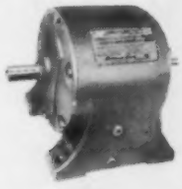


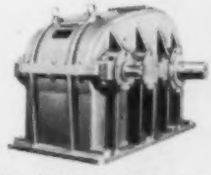
Integral Gearmotor



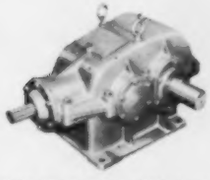
All Motor Gearmotor



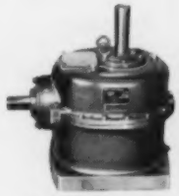
StraitLine Reducer Double Reduction Type RD



Parallel Shaft Reducer

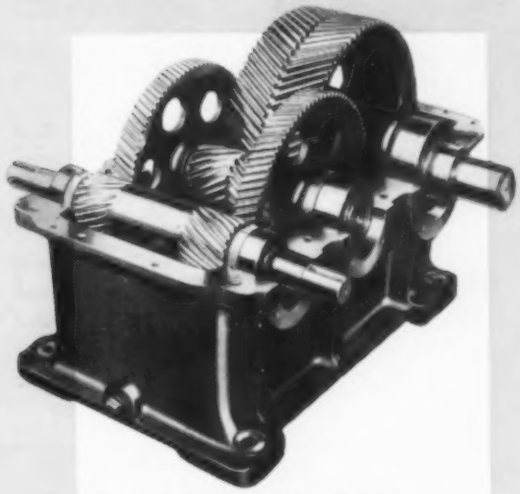


Right Angle Speed Reducer



Vertical Reducer

why these **10** outstanding features of *WESTERN GEAR* speed reducers are important to you!



- Double helical hardened steel gears, symmetrically arranged, provide balanced loading and long life.
- Better than average overhung load capacity.
- Heavy duty antifriction bearings assure greater than standard bearing life.
- Engineered to prevent oil leakage.
- Pinions integral with shaft for maximum strength.
- Rugged, rigid, ribbed housings.
- Simple, trouble-free splash lubrication system suitable for reversing service.
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- Rated in accordance with AGMA standards.
- Backed by Western Gear's reputation and the experience gained in 69 years of designing and manufacturing power transmission equipment.

Western Gear speed reducers, with the "10 outstanding features" listed above, are available to you in a full line with ratings to 10,000 HP, in any desired ratio. Shaft arrangements in horizontal or vertical parallel shaft, in-line, or right angle with horizontal or vertical shaft. Western Gear's complete family of mechanical power transmission products PLUS skilled application engineering service promise you the right answer whether you are building an entire installation or modernizing old equipment. Call your "Western Gear Man" for the answers.

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Crops *and* Shorts

There's a strange reversal going on in the thinking of many people. The old independent spirit, the will to take a chance to get ahead, the desire to stand on one's own feet are fast disappearing. Years ago, paternalism on the part of employers was resented. Now, insurance of all types, pensions, unemployment pay, etc., are uppermost in many minds.

To top it all, hotel and restaurant employees in Los Angeles are asking for a prepaid legal care plan for all, financed, of course, by employers. Can you imagine the rash of lawsuits? A barristers' paradise!

At the risk of setting up new demands, we might ask what about supplying and maintaining automobiles? Or what's the matter with living expenses? Grocery bills are pretty high now.

Incidentally, the Los Angeles hotel and restaurant employees already have a dental care plan which is costing twice the forecast—which isn't surprising. Anything that's free will be used wastefully.

We'll soon have the old British "cradle-to-grave" care plan backed off the map.

▲

One-fourth of last year's 2,900,000 college students were married—a great many were parents. Educators view this condition with mixed reactions. It results in a settled attitude and good scholarship but reduced campus activity. Some think it stifles ambition. Married students want security. They are not so willing to take chances. Many seem to want only a simple life. And the trend is expected to continue.

▲

Even the old habit of kissing the children goodnight seems doomed. We can't stay up till they come home.

▲

The month of May saw Hazel blast furnace at U. S. Steel's Fairless works set a new production record for the second successive month. In April, this furnace produced 62,370 tons for a daily average of 2079 tons. In May, production totaled 66,395 tons, an average of 2142 tons per day.

It isn't really true that Treasury Secretary Humphrey quit golf because, when he stepped up to the tee, he couldn't avoid thinking about the budget and couldn't help slicing.

▲

Lewis L. Strauss, chairman of the U. S. Atomic Energy Commission told members of the American Iron and Steel Institute that, in 20 or 25 years, the United States would have 227,000,000 kw capacity of nuclear-powered generation, or about one-third of the total at that time.

▲

A friend of ours says a fine remedy for insomnia is to take a shot of bourbon at regular intervals. It doesn't make him sleep but it makes him happy to stay awake.

▲

Lehigh University reports the starting salaries of its 1957 engineering graduates to average $465 a month, 11 per cent above last year.

▲

In spite of the slackened pace of 1957 steel production, U. S. mill shipments of tinplate for the first four months totaled a record 2,577,771 net tons.

▲

No one who has ever grown roses uses the phrase "a bed of roses" to denote a soft snap—unless his wife likes to garden.

▲

Punch-card systems for automatic screw-down control are finding acceptance, with most of the major steel producers buying them.

▲

U. S. Steel's ferromanganese blast furnaces at Duquesne works show tonnage increases of 30 per cent—part attributed to better burden but principally from enrichment of the blast to 26 or 27 per cent oxygen.

▲

Consumption of electric power in the iron and steel industry averaged 311 kwhr per ton of ingots in 1956. In 1947 the average was 248 kwhr per ton of ingots.

▲

Romance: Dating, Doting, Debting.

▲

An automatic survey indicates that car-buyers are, more and more, "demanding" power-assisted optional equipment and other extras. And at the same time, we hear them complaining about the price of cars.

FIRST 2 OXYGEN CONVERTER INSTALLATIONS IN THE UNITED STATES EC&M CONTROLLED!

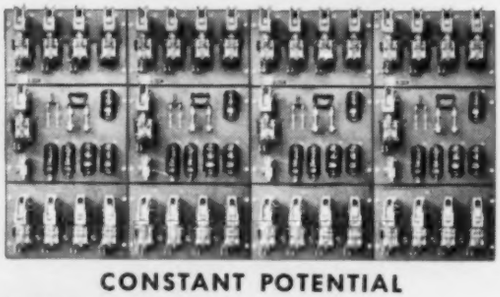
for basic steel making... it's EC&M CONTROL

EC&M control has proved itself by years of consistent performance in basic steel making processes —ore handling, hearth charging, ladle cranes, hot metal mixers, Bessemer converters.

The same exacting standards of safety and efficiency have been designed into the EC&M equipment which controls the new Oxygen Converter process.

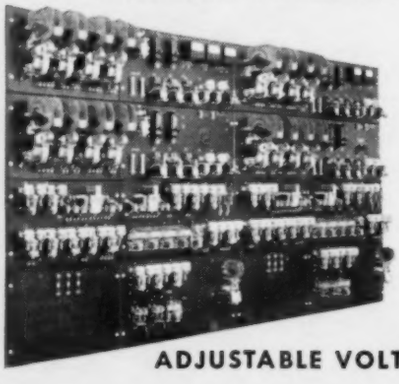
You'll find your nearby Field Engineer a source of sound counsel in solving any electrical control problem.

2 Types of Control for 2-Motor Vessel Tilt Drives

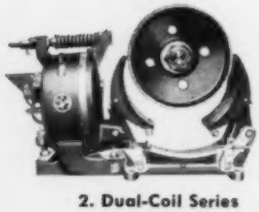


CONSTANT POTENTIAL

1. Speed Control Master Switch



ADJUSTABLE VOLTAGE



2. Dual-Coil Series or Shunt Wound Brakes

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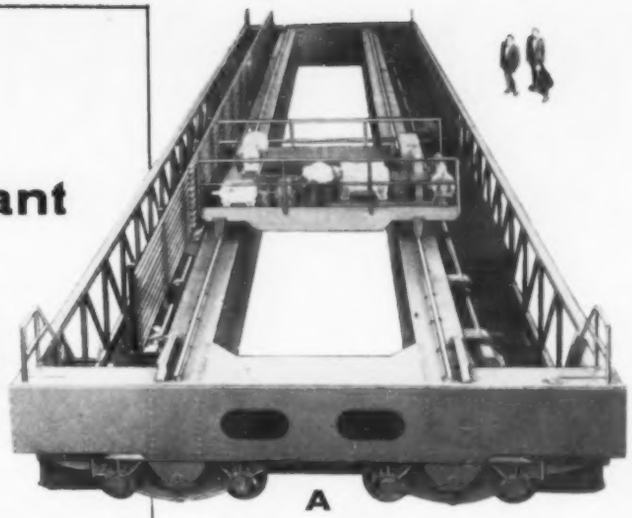
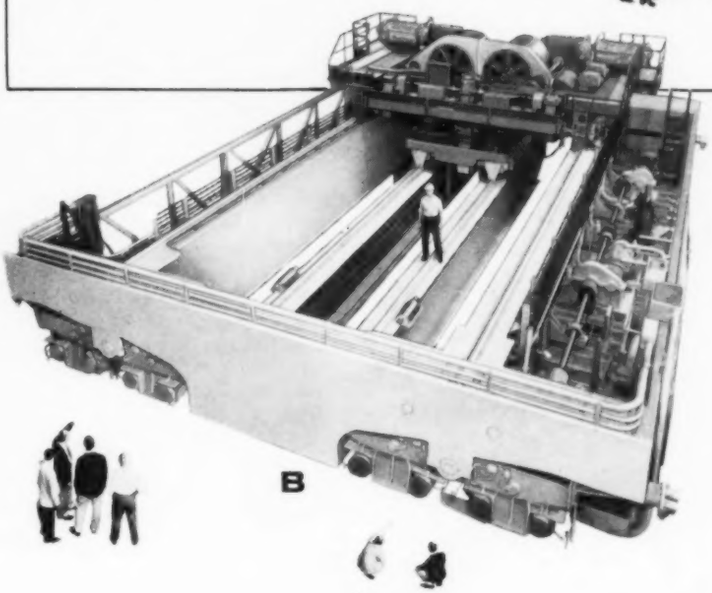


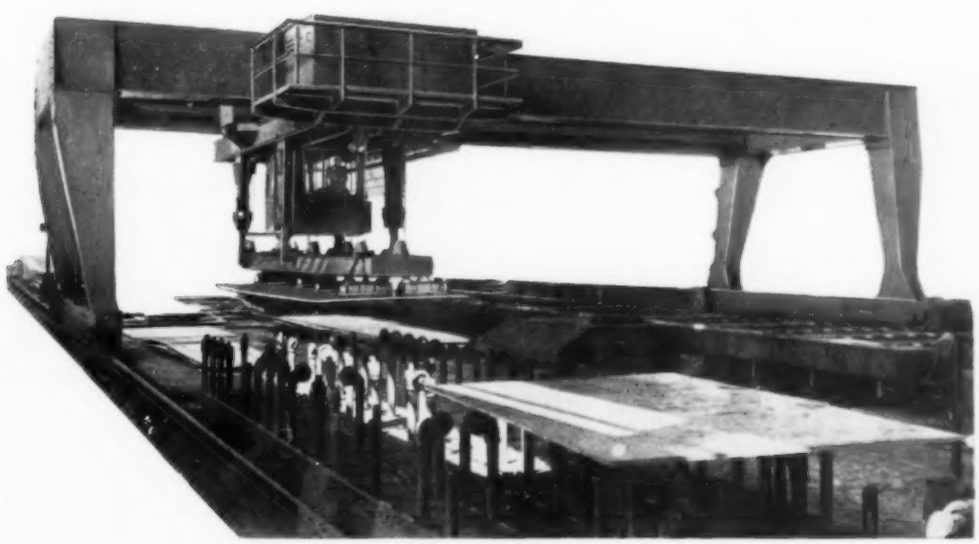
A



B

"Shaw-Box" Cranes are built exactly to specifications — your own or AISE Standard Specifications No. 6. Whether your plans call for a plate or slab handling crane, a soaking pit carriage, or a ladle crane, the long experience and vast facilities of Shaw-Box can save you time, trouble and money.

Make sure your next mill crane has the strength and rugged construction essential for 'round the clock service — plus economical operation. One of our engineers will gladly discuss specifications and tell you of our standard AISE designs for 15 to 200-ton cranes. Your inquiry is invited.



C

The pictures:
(A) *25-ton, 100-foot span mill crane.* **(B)** *Ladle crane that handles 200 tons of molten steel in 90-ton ladle.* **(C)** *Plate handling gantry with lifting magnets. All have exclusive Shaw-Box structural, mechanical and operational advantages that assure reliable performance.*

57K-2

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SHAW-BOX CRANE & HOIST DIVISION
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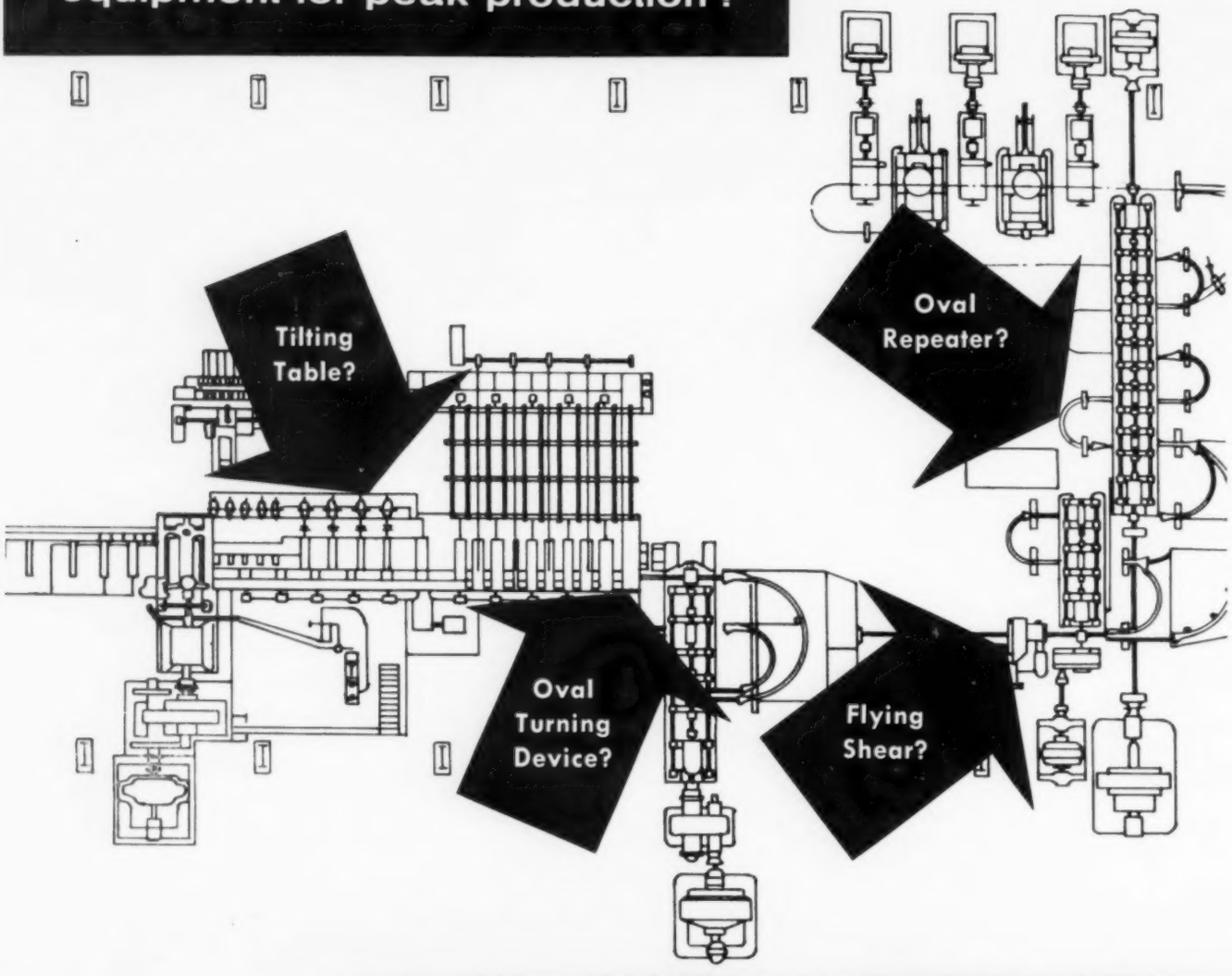

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Customer's Report

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"The fewer the parts to wear—the less to take care of—"

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Maintenance is more than ever an important consideration when purchasing new equipment. An interruption in production today quickly absorbs narrow profit margins.

A study of annealing furnaces for a given tonnage dramatically shows the Lee Wilson Single Stack to have 18 to 49% fewer items requiring service—thus, a correspondingly smaller chance of costly breakdowns. This is another big reason why more and more steelmakers are turning to Single Stack furnaces by Lee Wilson for all their annealing requirements.

Only Lee Wilson Furnaces Give You All These Advantages

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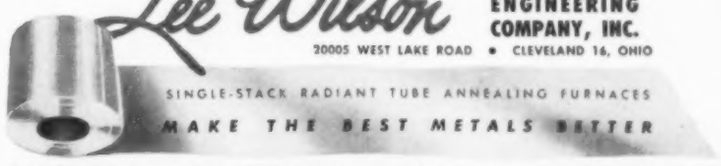
8. BETTER OPERATING CONDITIONS
9. LOWER MAINTENANCE COST
10. REDUCED INSTALLATION COSTS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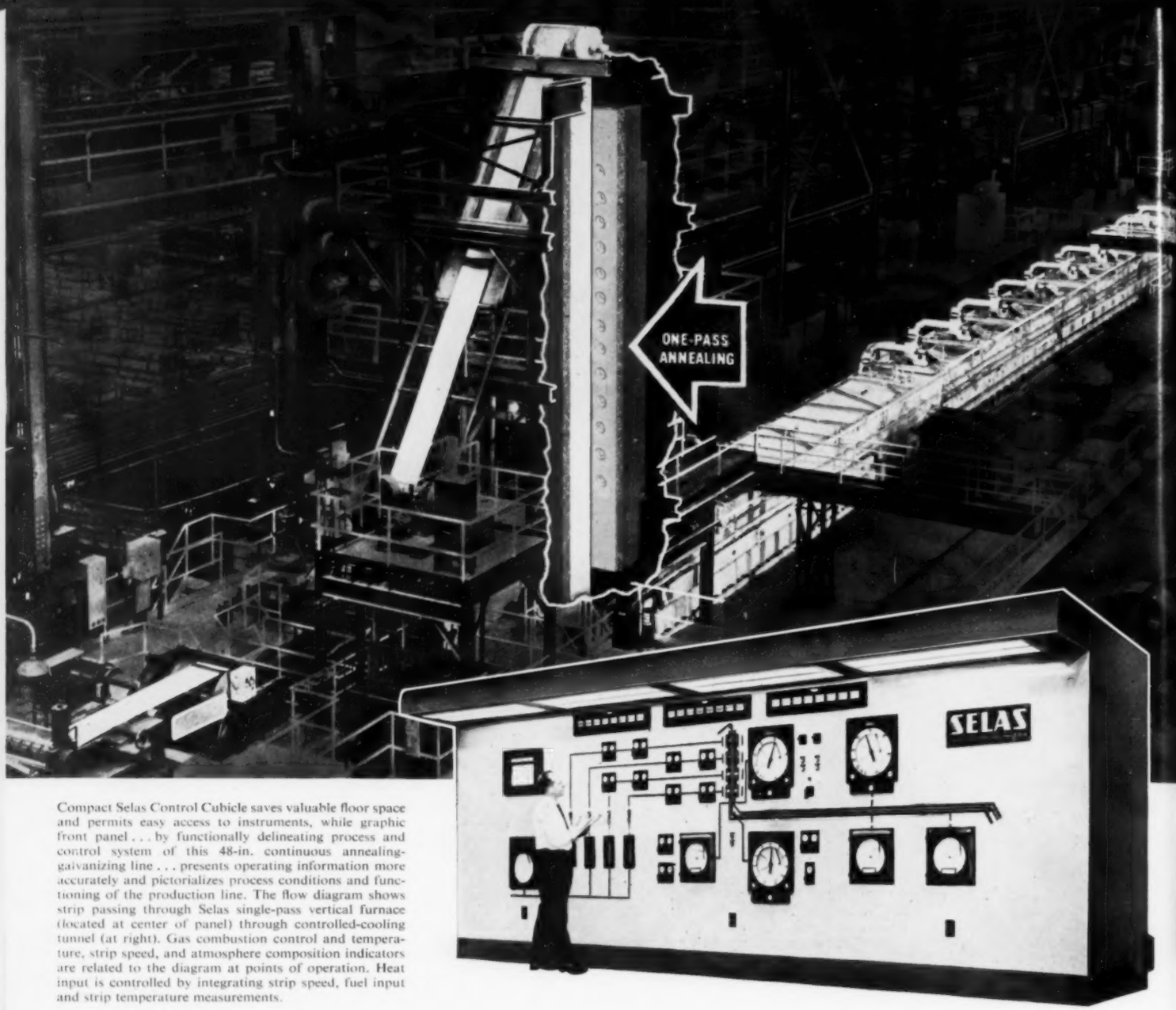
SINGLE-STACK RADIANT TUBE ANNEALING FURNACES
MAKE THE BEST METALS BETTER

* ORIGINATORS AND LEADING PRODUCERS OF SINGLE-STACK RADIANT TUBE FURNACES

375

* MAINTENANCE ITEMS FOR 100,000 TONS PER MONTH

	SINGLE STACK 72 FCE. 198 PED.	4-STACK 29 FCE. 320 PED.	8-STACK 18 FCE. 432 PED.
Base fan motors	198 (15 H.P.)	320 (15 H.P.)	432 (15 H.P.)
Base fans	198	320	432
Heater tubes	720	725	900
Burners	720	725	900
Thermocouples (base)	198	320	432
Furnace blower motors	72 (5 H.P.)	29 (10 H.P.)	18 (20 H.P.)
Instruments	72	58	36
Inner covers	198	320	432
Gas pressure regulators	72	29	18
Thermocouples (Fce.)	72	58	36
Bases (pedestals)	198	320	432
Total maintenance items	* 2,718	* 3,224	* 4,068
% Increase	—	18.6	49.0



Compact Selas Control Cubicle saves valuable floor space and permits easy access to instruments, while graphic front panel . . . by functionally delineating process and control system of this 48-in. continuous annealing-galvanizing line . . . presents operating information more accurately and pictorializes process conditions and functioning of the production line. The flow diagram shows strip passing through Selas single-pass vertical furnace (located at center of panel) through controlled-cooling tunnel (at right). Gas combustion control and temperature, strip speed, and atmosphere composition indicators are related to the diagram at points of operation. Heat input is controlled by integrating strip speed, fuel input and strip temperature measurements.

Process Controlled Strip Heating with Selas Gradiation® Heating

Steel strip is delivered continuously to the galvanizing bath, fully annealed and at temperature conditions best suited to the production of highest quality galvanized sheet . . . by the combination of Selas process control and Selas Gradiation heating.

The control cubicle, by visually relating the instrumentation to the processing flow diagram, simplifies process control and pictorializes functioning of the production line.

The Selas direct-fired heating principle is used in other continuous strip applications, including:

Bright annealing of steel . . . stainless steel annealing . . . tin reflow . . . galvanizing-annealing . . . preheat for galvanizing . . . preheat for annealing . . . bluing . . . special coatings . . . brass annealing.

In all these operations, radiant gas heat, precisely applied across the strip width, increases heating speed and produces unsurpassed uniformity in product quality.

- Compact single-vertical-pass design saves valuable floor space . . . avoids rolls in heated section, eliminating accompanying maintenance and product quality difficulties.
- Elimination of externally-prepared atmosphere in heating section reduces operating costs.
- Precise thermal control assures reproducible uniformity, regardless of gauge variations.

The same benefits are also being achieved in continuous annealing of nonferrous metals.

Our engineers will be glad to discuss how Selas Gradiation methods can be tailored to your strip heat-processing needs. Address Dept. 47.

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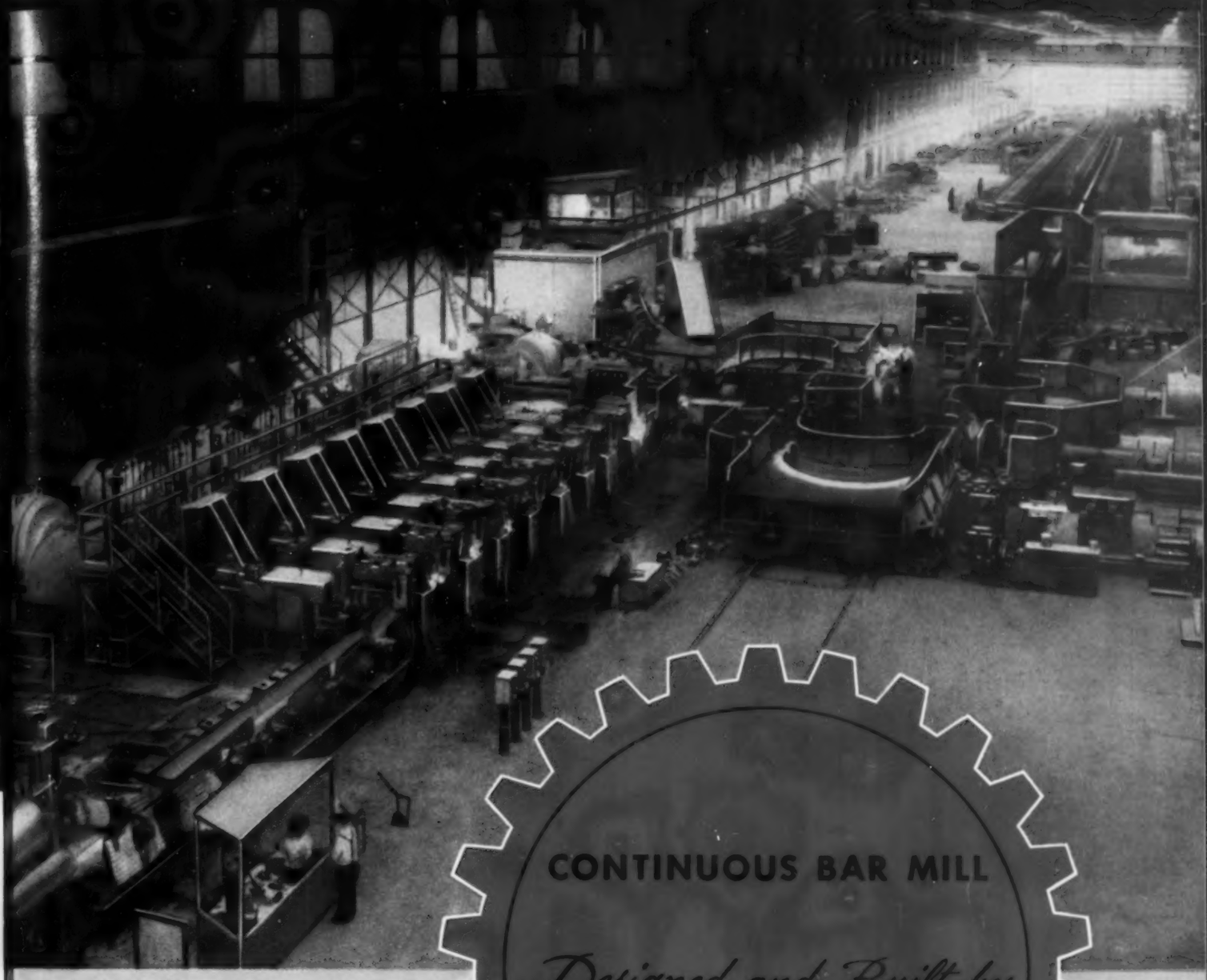
Heat and Fluid Processing Engineers

DEVELOPMENT • DESIGN • CONSTRUCTION



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- Advanced design . . . for low-cost maintenance and trouble-free operation.

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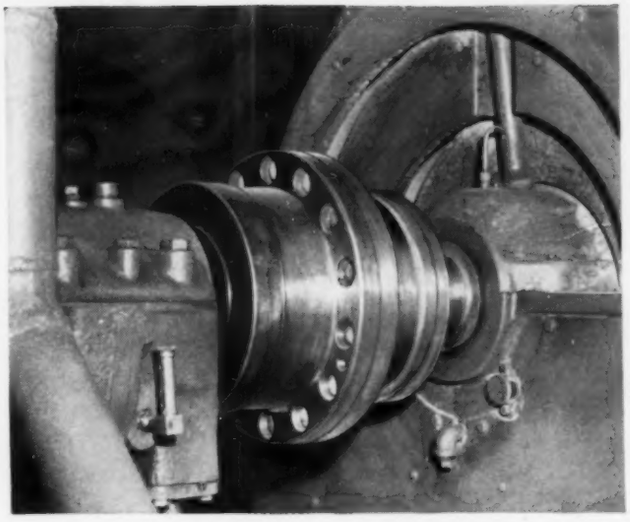
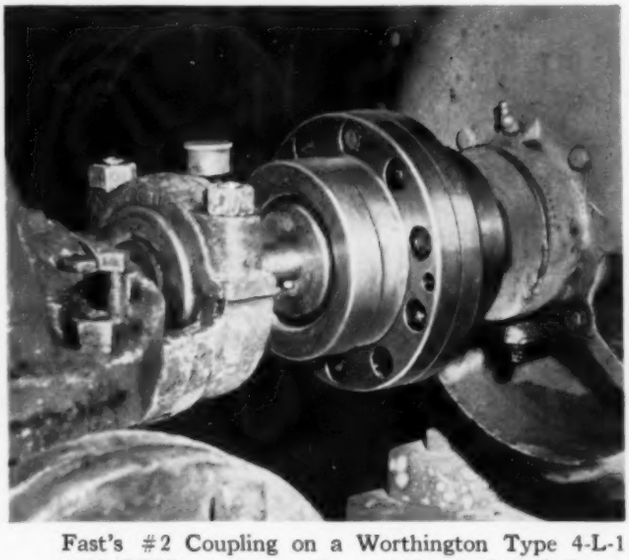
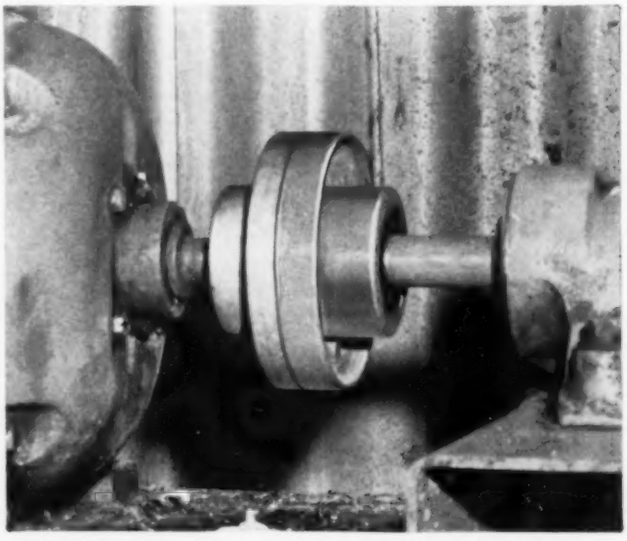


Fast's #4½ Coupling on a 1200 GPM Wilson-Snyder descaling pump. A 1500 hp., 1770 rpm motor drives the unit which operates at a head of 1250'.



Fast's #2 Coupling on a Worthington Type 4-L-1 1000 GPM pump operating at a head of 175'. Pump speed is 3570 rpm. Motor is 60 hp.



Fast's #1 Coupling on a 2500 CFM ventilating fan. Fan motor is 1½ hp. Rpm is 1800.

Detroit Steel Keeps 100 Fast's Couplings at Work with Only Minimum Maintenance

Fast's Couplings have reduced costly downtime and maintenance at Detroit Steel Corporation's Portsmouth, Ohio hot strip mill. Over 100 in number, they range in size from #1 to #20. Many of these couplings have operated with practically no maintenance for six years. Detroit Steel chose Fast's Couplings because of their *sound basic design.*

Here's why Fast's design pays off in low-cost maintenance and trouble-free performance: mechanical flexibility compensates for misalignment. Couplings last longer because there's no metal-to-metal wear. Positive lubrication forms a film on load-carrying surfaces. Metal-to-metal seal keeps out dirt, grit and moisture.

For more details, write to KOPPERS COMPANY, INC., Fast's Coupling Dept., 3007, Scott St., Baltimore 3, Md.

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Engineered Products Sold with *Service*

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Lubricating oils, cutting oils, multi-purpose greases, greases for spraying . . . whatever your needs, Atlantic has the lubricant to help you. Atlantic lubricants insure maximum lubricating performance at low cost for every job in the plant . . . for every wheel that turns in industry.

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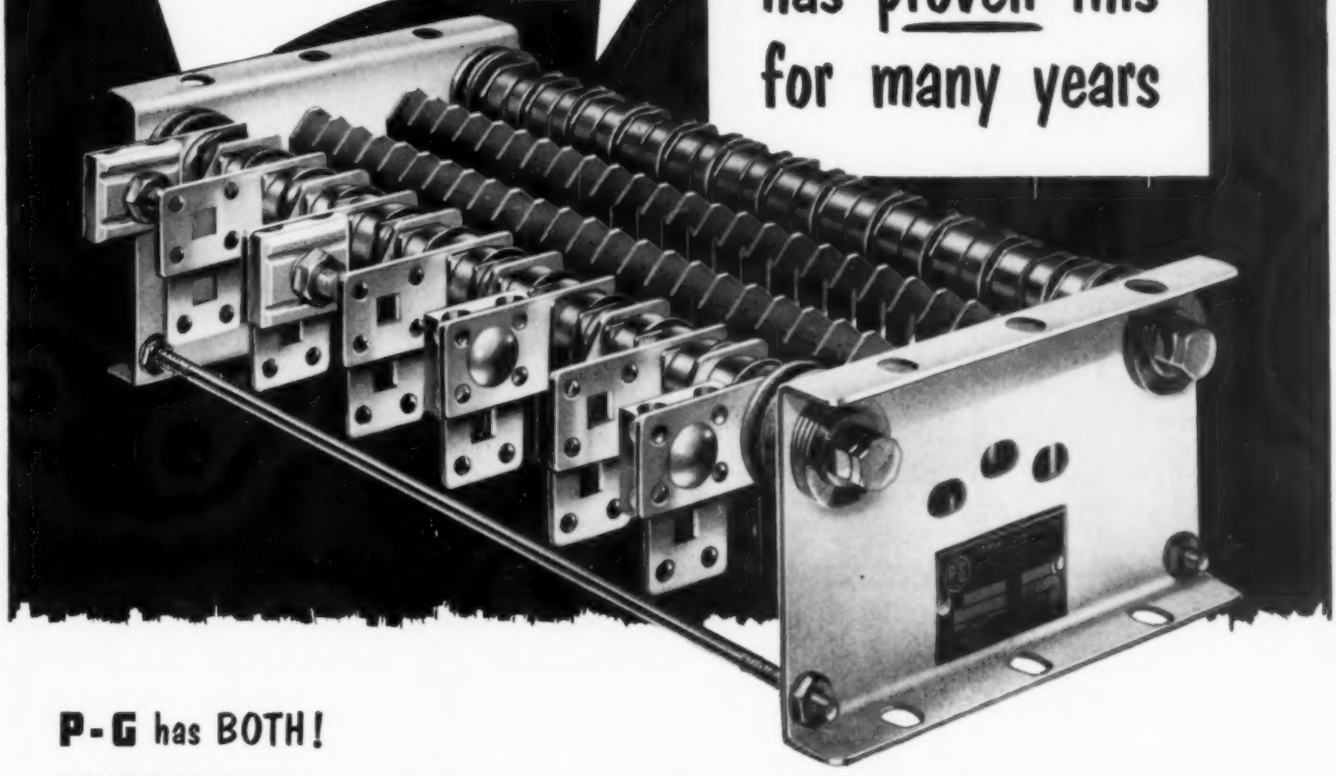
P-G the ORIGINAL Steel Grid Resistor has proven this for many years



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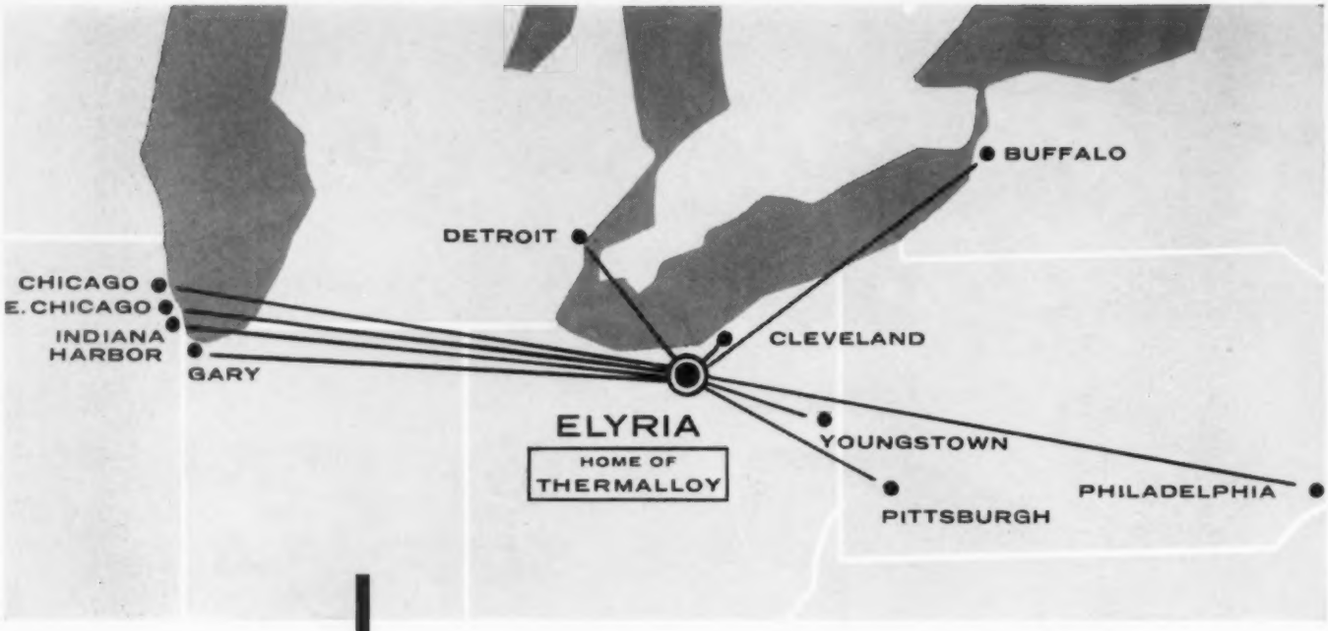

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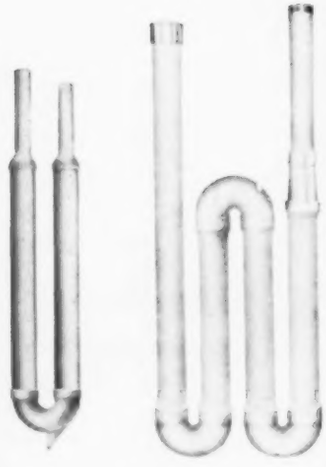
Perhaps you haven't. But the map shows how centrally located it is to major steel-producing centers . . . an advantage our steel mill customers seem to like.

If you *are* here sometime, we'd like to show you through our Electro-Alloys plant—one of the most modern alloy foundries in the country. You'll see a lot of steel mill parts being cast, too—because our steel-industry customers have found that *THERMALLOY** heat-resistant castings give long-life economy in many tough applications.

If you can't visit us, call our nearest sales representative. He'll put our expanded facilities to work for you on any high-heat-resistant casting requirement you may have, such as the parts shown below. Electro-Alloys Division, 8067 Taylor St., Elyria, Ohio.

*Reg. U.S. Pat. Off.



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Centrifugally cast, X-ray controlled, pressure-tested.

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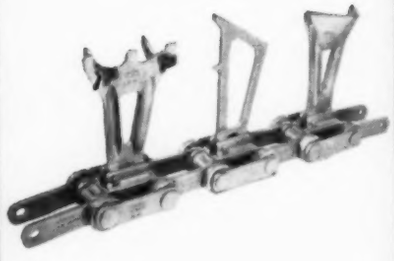
...for roller-bottom furnaces.



Thermalloy Carrier Blades and Chain ...Three types of blades, mounted on *Thermalloy* conveyor chain.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION Elyria, Ohio

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Patent Reviews

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents cover period January 29, 1957 through February 19, 1957 . . . .

APPARATUS FOR FOLLOWING AN EDGE OF A STRIP

▲ U. S. 2,779,549, issued Jan. 29, 1957 to Alfred Teplitz and assigned to United States Steel Corp., describes a scanning device for use in conjunction with strip position control devices.

As shown in Figures 1 and 2, the mandrel 2 of an uncoiling reel is mounted in a housing 4 which is slidably mounted on a base 6. A hydraulic cylinder 8 is mounted on the base 6 and has its piston rod 10 attached to the housing 4. The strip S passes from the mandrel 2 over rolls 12R and 12L, which are mounted on a bent shaft 14. The flanges 32R and 32L of the rolls follow the edges of the strip S. Rollers 38R and 38L are positioned in the grooves 36R and 36L, and are linked as shown. Because of the geometry of the linkage, pin 48 will always be midway between rollers 38R and 38L, and will move exactly the same amount as the deviation of the strip.

The operation of the apparatus is as follows: when the center line of the strip is in the desired position, the pressure applied to the diaphragm 64 will be exactly balanced by the spring 68, so that equal pressure will be applied to both sides of the piston of cylinder 8. When the center line of the strip moves from the desired center line, the link 44 will be moved from the centerline a proportionate amount. As shown in Figures 2 and 3, the portion of link 44 extending beyond pin 48 is cut away to the common centerline between pins 42

Figure 1

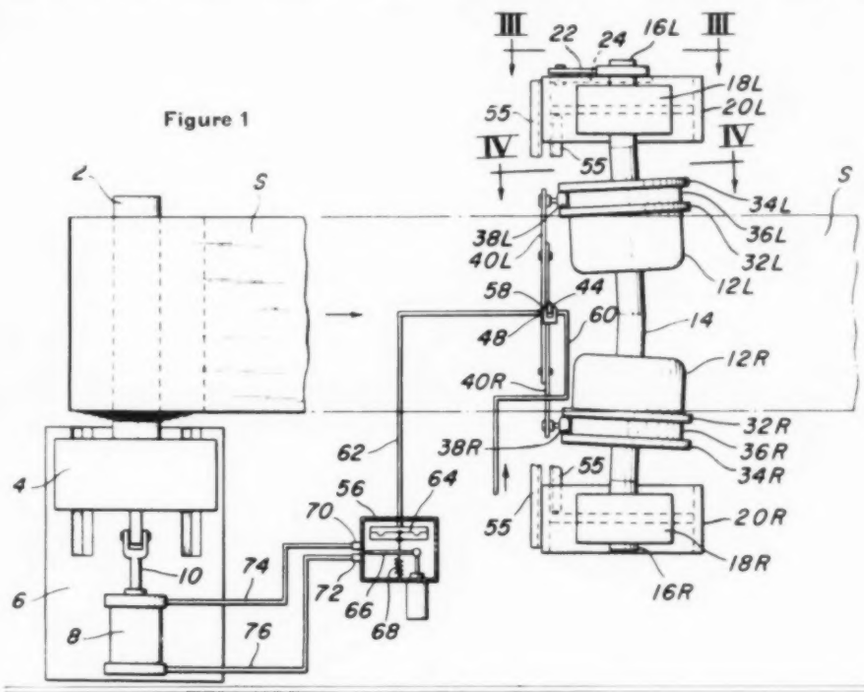


Figure 2

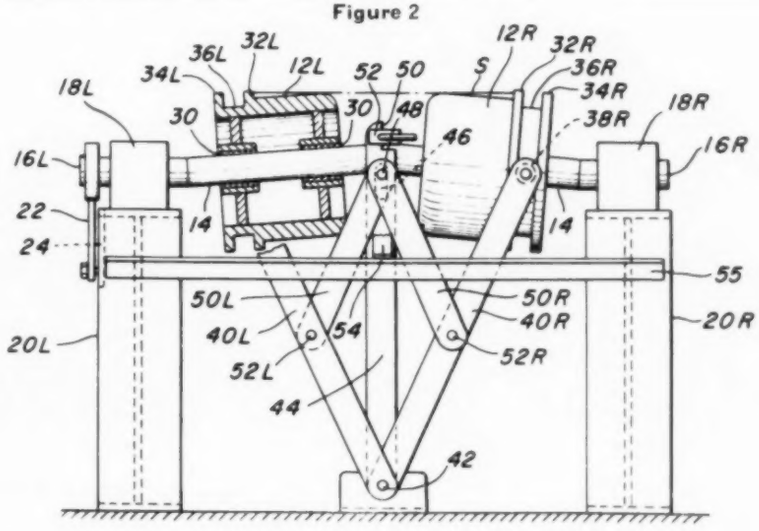
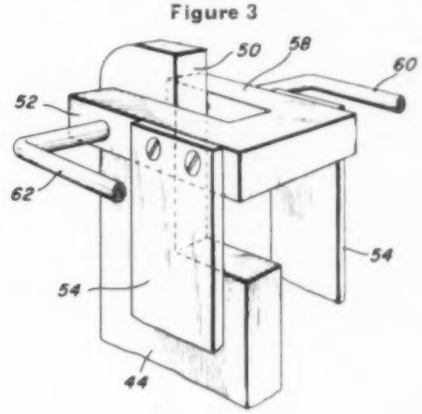


Figure 3



and 48, so as to provide an edge 50 which locates the centerline of the strip. The motion of this edge 50 determines the amount of air which can get from the air supply line 60 to the recovery orifice leading to line 62. The recovered air pressure is applied to one side of a diaphragm 64 located in the regulator 56, and is a direct measure of the position of edge 50. The pressure on the diaphragm 64 will increase or decrease, depending on which direction the edge 50, and hence the centerline of the strip, has moved. This in turn causes the jet pipe 66 to move to direct a greater amount of oil into one of the orifices 70 or 72 and hence causes more oil to flow to one side of the piston in the cylinder 8, so that the piston rod 10 will move the mandrel 2 in a direction which will bring the centerline of the strip back to the desired position.

FLEXIBLE BUSHING AND MOLD STOOL FOR CAST TUBULAR INGOTS

▲ U. S. 2,779,676, issued Jan. 29, 1957 to Benjamin Brownstein, describes a mold and core for casting a tubular ingot which is clean and smooth, free from shrinkage cracks, blow holes, sand holes and fused sand, and in which oxidation and scaling of the ingot bore are avoided. Advantage is taken of the natural tendency of the shrinking ingot upon solidification to grip the core utilized to impart the tubular formation. A flexible or yieldable centering cone or core is used, and an asbestos protective liner or flexible bushing is added concentric with the flexible core. As the ingot shrinks, it firmly grips the flexible bushing. The flexible core is then removed from the mold and the bushing or liner remains behind, adhered to the bore of the ingot. The bushing protects the bore from oxidizing and scaling, regardless of any subsequent heating and cooling. Furthermore, when the ingot is eventually rolled over a supporting member such as a mandrel, the flexible bushing functions as a lubricant to facilitate the rolling operation and prolong the life of the mandrel.

The asbestos is crushed and pulverized into a fine powder during the rolling operation by the enormous force exerted by the mill rolls. When the finished tube or pipe emerges from the last roll pass, there remains only a fine asbestos powder in the bore of the finished tube, which is easily removed by blowing.

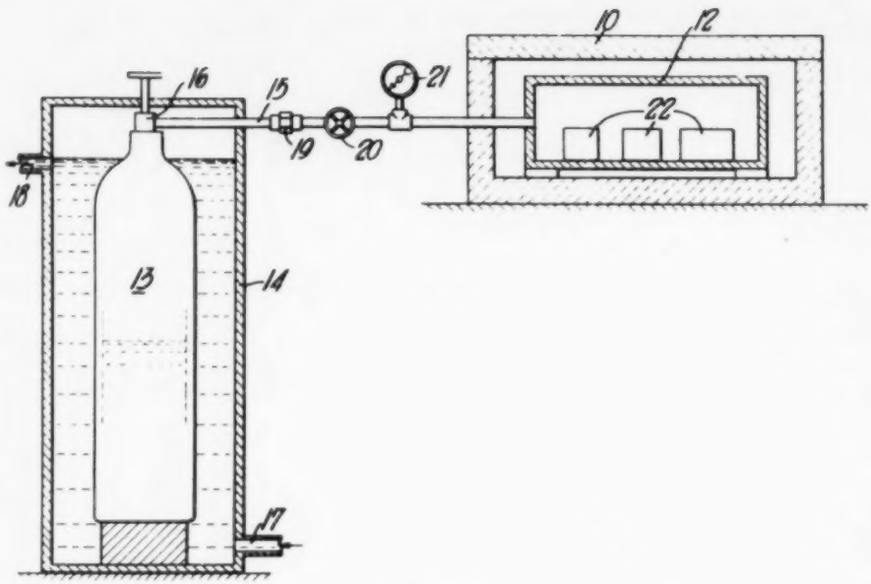


Figure 4

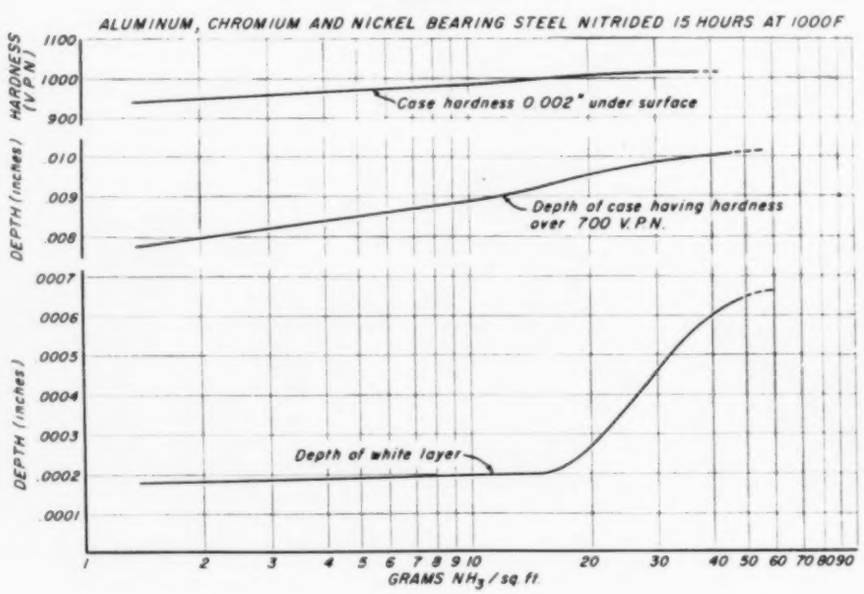
METHOD OF NITRIDING METALLIC SURFACES

▲ U. S. 2,779,697, issued Jan. 29, 1957 to Roy L. Chenault and Gerald E. Mohnkern, assigned to United States Steel Corp., describes improved methods of nitriding steel surfaces with ammonia, without the need for a capsule for charging the ammonia, and without producing a "white layer" on the nitrided surface.

One of the methods described in the patent is shown schematically in Figure 4. The apparatus consists of a furnace 10, a sealed nitriding chamber 12 within the furnace, an ammonia supply tank 13, a water jacket 14 surrounding the ammonia tank, and a pipe 15 connected between tank 13 and chamber 12. Chamber 12 contains workpieces 22 to be nitrided.

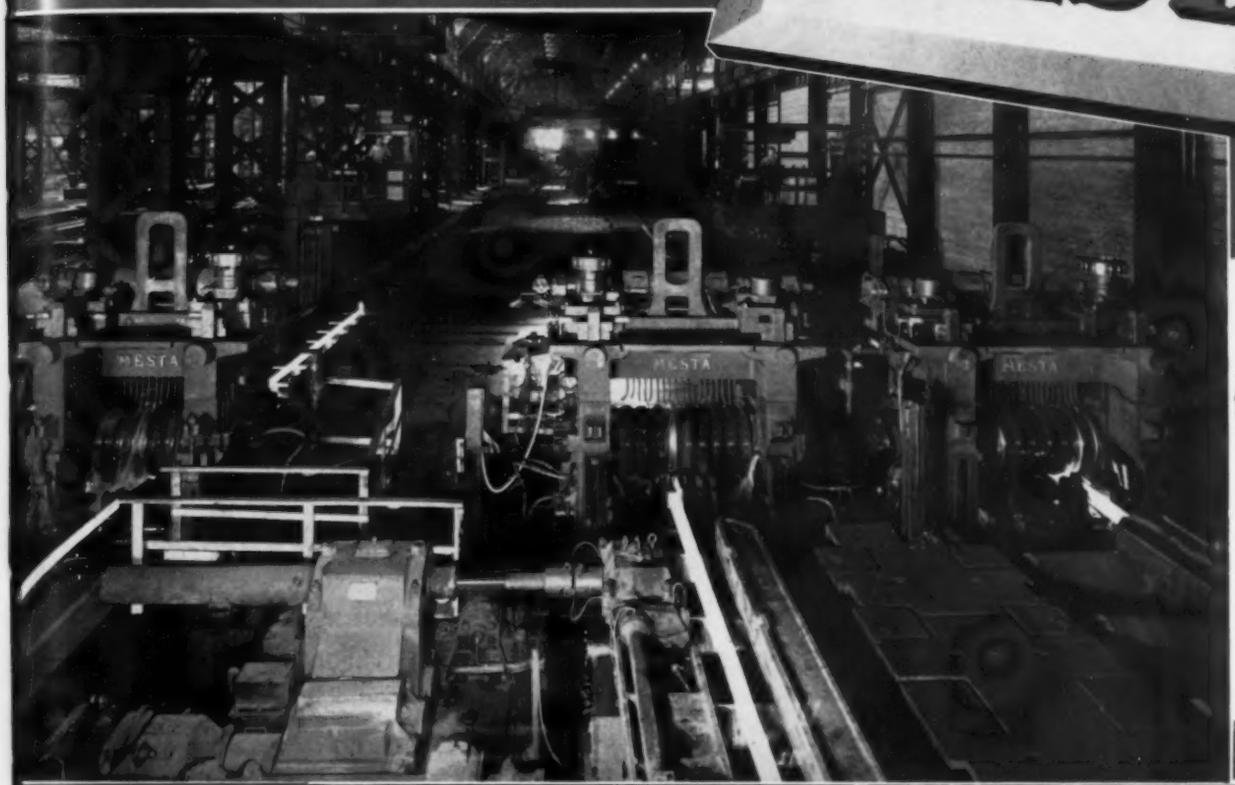
Tank 13 contains both liquid ammonia and ammonia vapor under pressure. The water in jacket 14 is maintained at a controlled temperature to regulate the vapor pressure of the ammonia. The nitriding

Figure 5



BAR and BILLET Mills

Designed and Built by MESTA



Intermediate, Leader, and Finishing Stands of a MESTA 32" Bar Mill

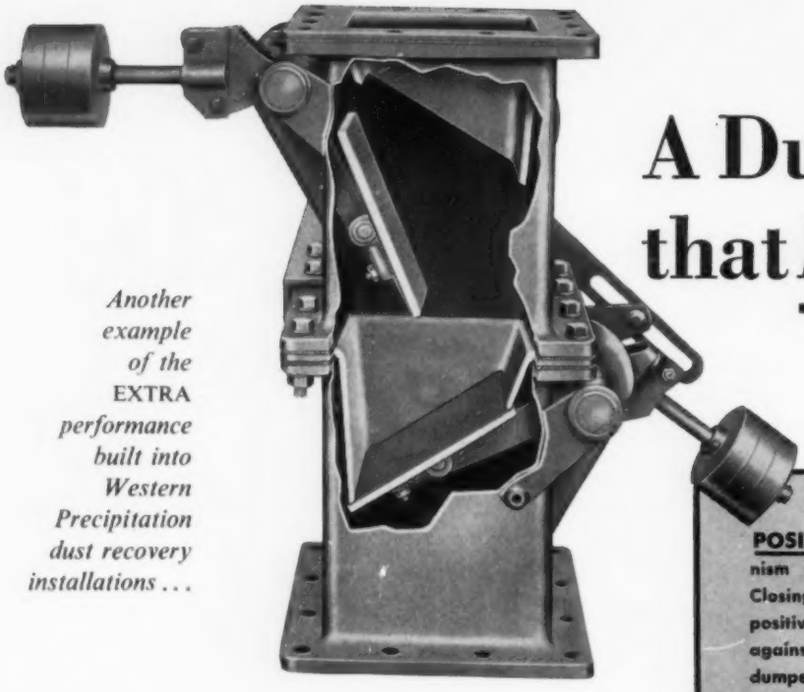
Two stands of a MESTA 30" Two-High Continuous Billet Mill with Vertical Edger

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

MESTA
THERE IS NONE BETTER



Another example of the EXTRA *performance built into Western Precipitation dust recovery installations . . .*

A Dumping Valve that *Really Works**

No dust recovery installation is better than the valves controlling the dust flow out of the collection hopper – particularly in Sintering Plants where the system operates under substantial vacuum. Poorly-designed valves allow recovered dust to blow back into the system . . . cause troublesome draft losses . . . air infiltration . . . and cut down efficiency of even the best recovery systems.

But – typical of the extra care Western Precipitation puts into *every* recovery installation – is the *Western Precipitation R-1 Dust Valve* . . . an automatic dust valve that is unsurpassed for trouble-free operation and maximum working efficiency. Check the features at right and you'll see why . . .

POSITIVE ACTION: Electric motor-driven mechanism provides positive opening on time-cycle basis. Closing is by gravity – and is adjustable. Thus, valve positively opens even with lightweight materials or against high vacuum . . . closes only after material is dumped.

DOUBLE-FLAP SEALS: Two flaps open and close alternately on a positive cycle to insure continuous clean-out without allowing pressure surges into hopper.

GRAVITY FLUSHING: Gravity safety trip permits each flap seal to open automatically if overloaded, allowing flush-out of excess material. Valves then return automatically to time-cycle operation.

RUGGEDLY BUILT: All parts and seals are designed for heavy-duty service with minimum maintenance. Bearings are sealed against dust – are outboard-mounted to protect against heat and dust. Valve seats and flap seals are easily replaced. Motor is fully sealed and protected.

There are many other unique features your Western Precipitation representative will gladly explain. Or write direct!

* To date 15 steel companies have installed R-1 Valves . . . and every company has re-ordered additional installations!

The R-1 Valve is typical of the care that goes into every Western Precipitation product. Furthermore, no other organization – domestic or foreign – has had as many years of experience in all phases of recovery methods . . . *electrical* (COTTRELL), *mechanical* (MULTICLONE), *combination* electrical-mechanical (CMP) and *filter* (DUALAIRE). You get an experienced—*and unbiased*—recommendation from Western Precipitation.

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Reverse-Jet Filters
HOLO-FLITE Processors

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Precipitation Company of Canada Ltd., Dominion Square Building, Montreal

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chamber temperature is higher than that of the ammonia tank temperature, so that no condensation of liquid ammonia occurs in the nitriding chamber. Ammonia vapor in the nitriding chamber will thus be in a superheated condition, with its pressure determined by the vapor pressure of liquid ammonia in the tank. Knowing the temperature and pressure, and the volume of the nitriding chamber, the mass of ammonia charged can be determined.

After the desired charge of ammonia has been introduced to the nitriding chamber, valves 20 and 16 are closed, and the chamber is heated to the nitriding temperature (i.e., 800 to 1200 F). Nitriding takes place over about a 15 hour period. The reversibility of the dissociation reaction assures a continuous supply of nascent nitrogen.

The amount of ammonia charge to be used can be determined from graphs such as that shown in Figure 5. The patent also contains similar graphs for aluminum-chromium bearing steel, and AISI 4140 steel.

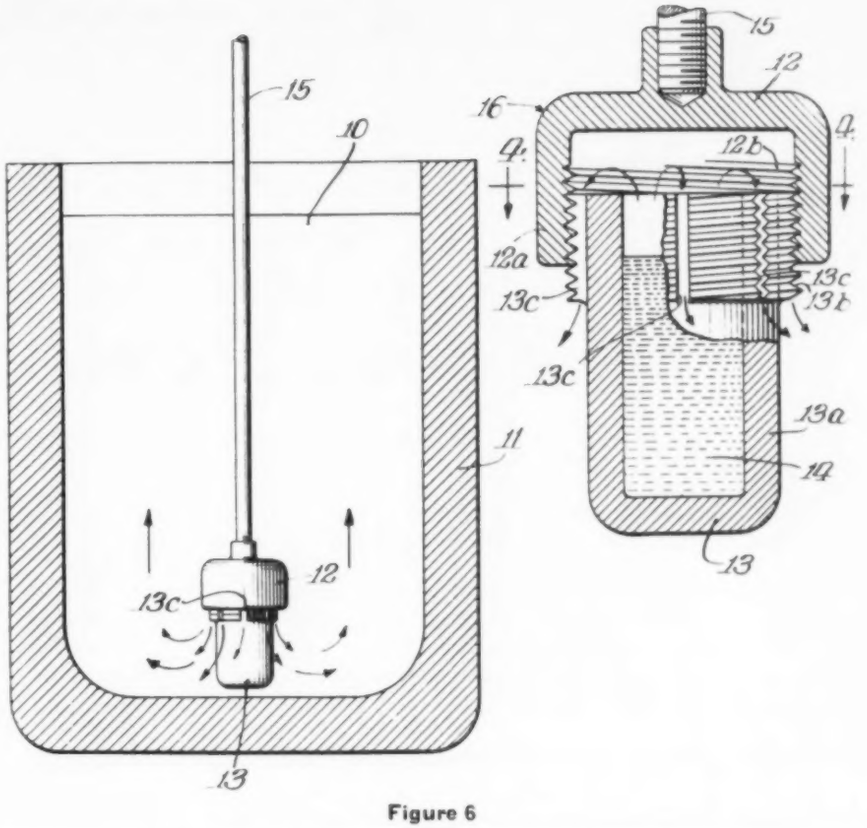


Figure 6

METHOD OF IMPROVING THE MACHINABILITY OF STEEL

▲ U. S. 2,779,698, issued Jan. 29, 1957 to Robert W. Baughman and Raymond A. Grange, assigned to United States Steel Corp., describes a method of improving the machinability of carburizing grades of steel.

It is common practice to normalize, or normalize and temper, carburizing grades of steel prior to machining and carburizing. This frequently causes a "gummy" condition which results in a rough machined surface, because the steel is soft and striated, i.e., contains bands of ferrite.

According to the present patent, the rough machined surface resulting from this treatment can be eliminated, and a smooth unpitted surface obtained by treating ferritic steel containing less than 0.3 per cent carbon. Such steel in the as-rolled or as-forged condition is heated or "austenitized" at a temperature determined by the formula

$$T_A = Ae_1 + \tfrac{2}{3}(Ae_3 - Ae_1)$$

where T_A is the furnace temperature, Ae_1 is the lower equilibrium temperature, and Ae_3 is the upper equilibrium temperature. The material is held in the furnace until the temperature of the workpiece is equalized at this temperature. The workpiece will then have a structure of about 50 per cent austenite and 50 per cent ferrite. This structure is not soft enough to give a "gummy" surface on machining, and not too hard for easy machining. The workpiece is cooled to the bainite range, i.e., to about 500 to 1000 F.

FLUE DUST SINTERING

▲ U. S. 2,780,536, issued Feb. 5, 1957 to Dennis J. Carney, assigned to United States Steel Corp., describes a method of sintering blast furnace flue dust for recharging into the furnace, and producing a higher strength of sinter than normal.

It has been found that the addition of a small amount of furnace slag to the mix used for sintering flue dust results in a product having materially increased strength, as well as good reducibility, and an iron content not substantially lower than normal. The slag may be either granulated blast furnace slag or open-hearth slag fines, the particles of which are less than $\frac{1}{8}$ in. in size. About 8 per cent by weight of slag is used.

METHOD OF MAKING KILLED RESULPHURIZED STEEL

▲ U. S. 2,780,540, issued Feb. 5, 1957 to Earl W. Pierce and assigned to United States Steel Corp., describes a process for making killed carbon or alloy steels in which sulphur is added after tapping from the melting furnace, in order to impart free machining qualities, without impairing its hot-rolling characteristics.

The method consists of melting and working a heat until the sulphur content is reduced below 0.030 per cent and, after tapping from the furnace, finally killing and resulphurizing it, and then adding to it about two lb of an iron-silicon-magnesium alloy (Mg: 6 to 12 per cent, Si and Fe: 30 to 50 per cent each) per ton of steel.

INOCULATING MOLTEN IRON WITH MAGNESIUM

▲ U. S. 2,780,541, issued Feb. 5, 1957 to Lothar R. Zifferer, describes a method of inoculating molten iron with magnesium, for the purpose of desulphurization and deoxidation, or for the purpose of producing spheroidal iron. Since magnesium is explosive when im-

No Excessive Heating

New Rectifier Cooling System Prevents Heat Build-up and Damage

when ac Power Fails

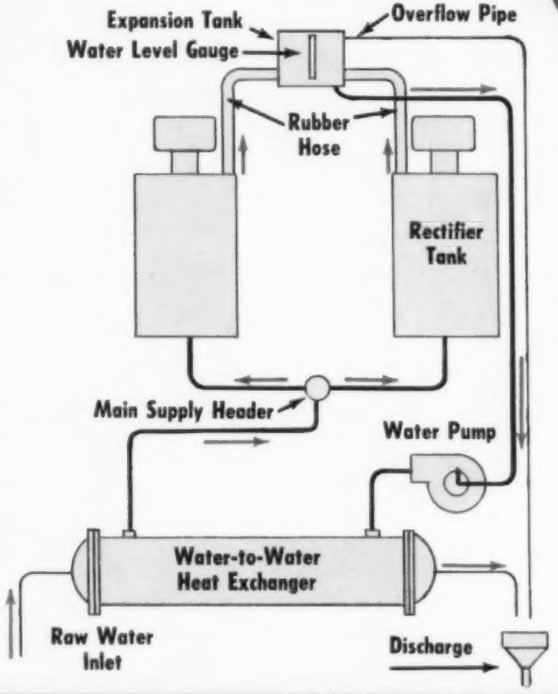
A SAFER, more effective cooling system in the Allis-Chalmers rectifier continues to circulate water *even when an ac power failure stops the water pump.* Heat and steam are dissipated before they can develop to the danger point.

The new system features an expansion tank that extends the full length of the rectifier frame with short vertical connections from each tube. With warm water continuing to flow freely upward, a thermo-siphoning action draws cooler water into the tubes. Build-up of excessive temperatures is prevented. Steam pockets are kept from forming. Subsequent water loss from the recirculating cooling system is minimized.

Successful operation in hundreds of installations is your assurance of the complete reliability of Allis-Chalmers mercury arc rectifiers. Contact your nearby A-C office or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.

How the System Works

Water is normally pumped through the water-to-water heat exchanger to the main supply header from where it circulates through rectifier tubes picking up heat. Hot water flows up through the short connections to expansion tank and back down to suction side of water pump.



ALLIS-CHALMERS
Mercury Arc Rectifiers

Factory-packaged units cut installation time and costs. Sealed tube rectifiers are supplied in completely enclosed or open types. Here is a typical, completely enclosed, 1000-kw, 250-volt rectifier for steel mill service.

ALLIS-CHALMERS

A-5425

mersed in ferrous baths, great precautions are necessary. Also, since magnesium is very expensive, wasteful methods must be avoided.

The method involves the use of an alloy of magnesium with a carrier metal such as aluminum. The alloy is immersed in molten iron at a temperature above the boiling point of magnesium, but below the boiling point of the carrier metal, aluminum. (This temperature will be above the melting point of the magnesium-aluminum alloy.) The inoculation occurs by means of the magnesium vapors which are evolved.

As shown in Figure 6, the magnesium-aluminum alloy 14 is contained in a container having a cup 13a and cap 12, which is immersed in a cylinder 11 of molten iron 10. The alloy is introduced to the cup 13a as a solid, and melts upon being immersed in the molten iron. Exit passages or grooves in the threads of cap 12 permit the evolved magnesium vapors to enter the molten iron bath and inoculate it, as soon as their vapor pressure slightly exceeds the hydrostatic pressure of the molten iron.

When the temperature within the alloy container becomes equal to that of the molten iron, heat transfer and consequent evaporation of magnesium ceases. This will occur at a definite concentration of magnesium in the magnesium-aluminum alloy, corresponding to this boiling point of the alloy.

Substantially no aluminum will evaporate, because its boiling point is much higher than magnesium.

TREATMENT OF FUMES CONTAINING SUSPENDED SOLIDS

▲ U. S. 2,781,255, issued Feb. 12, 1957 to William A. Krivsky and Erich K. Modl, and assigned to Union Carbide & Carbon Corp., describes a method and apparatus for the treatment of gases contaminated by metallurgical dust particles in the sub-micron size range, such as iron oxide particles.

The method involves passing the iron-oxide-contaminated flue gas through a heated column of coke particles. The entrained iron oxide particles are reduced to metallic iron in one portion of the column, and the flue gas is purified of suspended solids as it travels the length of the column. The reaction which takes place in the column is believed to be a combination of chemical reduction and adsorption.

Steam and/or oxygen may also be admitted to the coke column to control the reaction temperature in the reducing portion of the column. The iron may thus be recovered either in the solid or liquid state.

The following example is given in the patent: A 100-lb melt of pig iron was top blown, using pure oxygen to make steel. A typical, heavy reddish brown fume, consisting mainly of iron oxide particles of sub-micron size, was generated. This fume was passed through a six-ft graphite tube furnace of 3-in. diameter filled with uniformly sized one-in. coke particles, the coke column having a reducing zone temperature of about 1000 C. Using a Staplex air sampler to determine the solid content in the exhaust fumes, there was no evidence of the slightest trace of any solid particles in the gas.

RAPID REMOVAL OF SULPHUR AND SILICON FROM PIG IRON

▲ U. S. 2,781,256, issued Feb. 12, 1957 to John H. Richards and assigned to United States Steel Corp., describes a method for rapidly reducing the sulphur and silicon content of pig iron.

The process consists of treating a batch of molten iron of particular carbon, manganese, and silicon content with air and a molten neutral slag, the former being introduced under rigorously controlled conditions, whereby oxidation of carbon is substantially avoided.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,779,550	1/29/57	Apparatus for handling strip between a high speed and a lower speed line.	United States Steel Corp.
2,779,551	1/29/57	Crib for wire coil formed on stationary coiling block	United States Steel Corp.
2,779,579 2,779,580	1/29/57	Conveyor for high temperature furnaces	Schwarzkopf Development Corp.
2,780,078	2/5/57	Perforated belt evaporative cooler	United States Steel Corp.
2,780,118	2/5/57	Apparatus for rolling tubes	United States Steel Corp.
2,780,119	2/5/57	Method of avoiding lapped over seams in tubes formed in cross-roll piercing mills	The National Supply Co.
2,780,354	2/5/57	Protective package for the shipment of rods	Bethlehem Steel Co.
2,780,366	2/5/57	Door operating mechanism for horizontal coking chamber ovens	Koppers Co., Inc.
2,780,448	2/5/57	Method of mining coal	United States Steel Corp.
2,780,453	2/5/57	Continuous furnace for heating slabs	Fred B. Coffman and Floyd E. Davis
2,780,454	2/5/57	Work conveyor for heat-treating furnaces	Holcroft & Co.
2,780,537	2/5/57	Treating iron ores with CO in a fluidized bed to produce iron carbide	Per Otto Stelling
2,780,570	2/5/57	Air-hardening tool steel	Bethlehem Steel Co.
2,780,590	2/5/57	Self-sealing door for horizontal coke ovens	Koppers Co., Inc.
2,780,592	2/5/57	Electrolytic treatment of metal surfaces	Bethlehem Steel Co.
2,780,860	2/12/57	Special shaped wire	United States Steel Corp.
2,780,985	2/12/57	Apparatus for handling coils	Allegheny Ludlum Steel Corp.
2,781,179	2/12/57	Reel for rolling mill	Morgan Construction Co.
2,781,188	2/12/57	Means for cooling the load of a coil annealing furnace	Controlled Heat & Air Ltd.
2,781,190	2/12/57	Blast furnace tuyere	United States Steel Corp.
2,781,259	2/12/57	Wear-resistant ferrous alloy	Vanadium-Alloys Steel Co.
2,781,260	2/12/57	Introduction of desulphurizing elements into cast iron and steel	International Nickel Co., Inc.
2,781,283	2/12/57	Method of processing stainless steels	Allegheny Ludlum Steel Corp.
2,781,284	2/12/57	Graphitic high carbon-high vanadium steels	Allegheny Ludlum Steel Corp.
2,781,302	2/12/57	Regenerative coke oven structure	Didier-Kogag-Hinselmann, Koksofenbau und Gasverwertung A. G.
2,781,441	2/12/57	Traveling apparatus for welding horizontal joints between vertically disposed plates	United States Steel Corp.
2,782,022	2/19/57	Production of iron from powdered ore	Gerolf Strohmeier
2,782,115	2/19/57	Production of pig iron and steel, using a metallic composition in place of carbon	Anton Wimmer
2,782,119	2/19/57	Production of silvery iron	Interlake Iron Corp.
2,782,147	2/19/57	Preparation of coking blends	Societe des Acieries de Longwy (Societe Anonyme)

ANNOU

Increased capacity ratings

THE Timken Roller Bearing Company announces an increase in the capacity ratings of most series of Timken® tapered roller bearings. Increases range up to 39%. Most are in the neighborhood of 10%. Some are negligible.

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What led to these increases in Timken bearing capacities? Three things: First, a careful review of more than 6,000 different laboratory studies

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of Timken bearing performance on fatigue life machines. From these exhaustive studies, conducted on an organized, scientific basis since 1924, we keep learning more and more about predicting bearing life.

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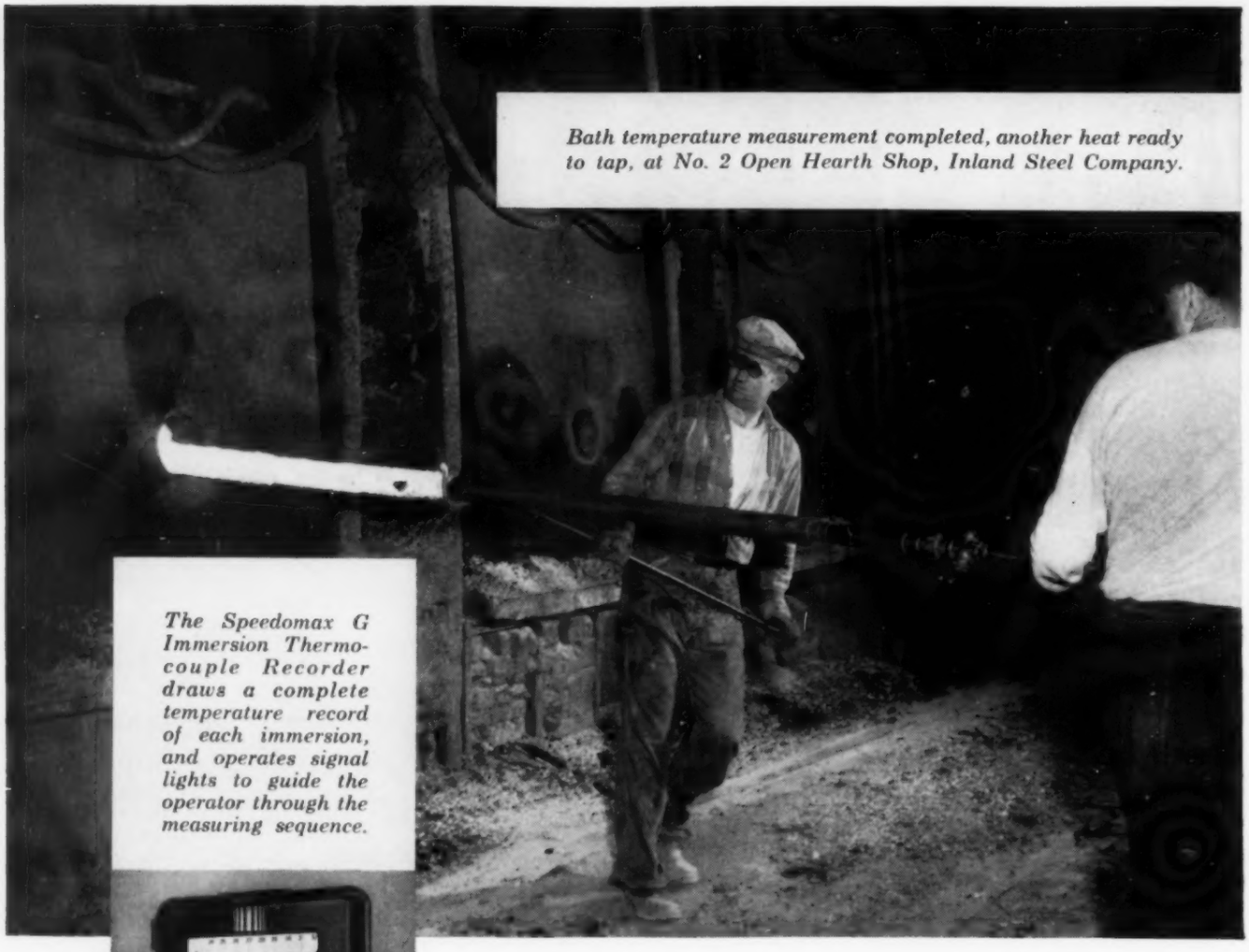
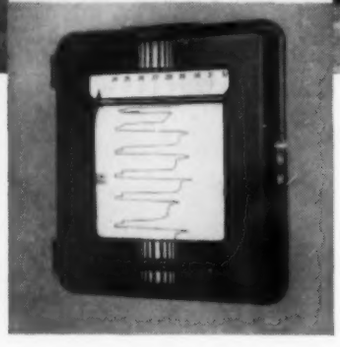
TAPERED ROLLER BEARINGS ROLL THE LOAD



Bath temperature measurement completed, another heat ready to tap, at No. 2 Open Hearth Shop, Inland Steel Company.

The Speedomax G Immersion Thermocouple Recorder draws a complete temperature record of each immersion, and operates signal lights to guide the operator through the measuring sequence.



World's largest open-hearth shop completely equipped with L&N Immersion Thermocouples

Teamwork, enthusiasm, and detailed planning enable the operators of No. 2 Open Hearth Shop at the Indiana Harbor Works, Inland Steel Company, to break production records and increase its annual capacity consistently.

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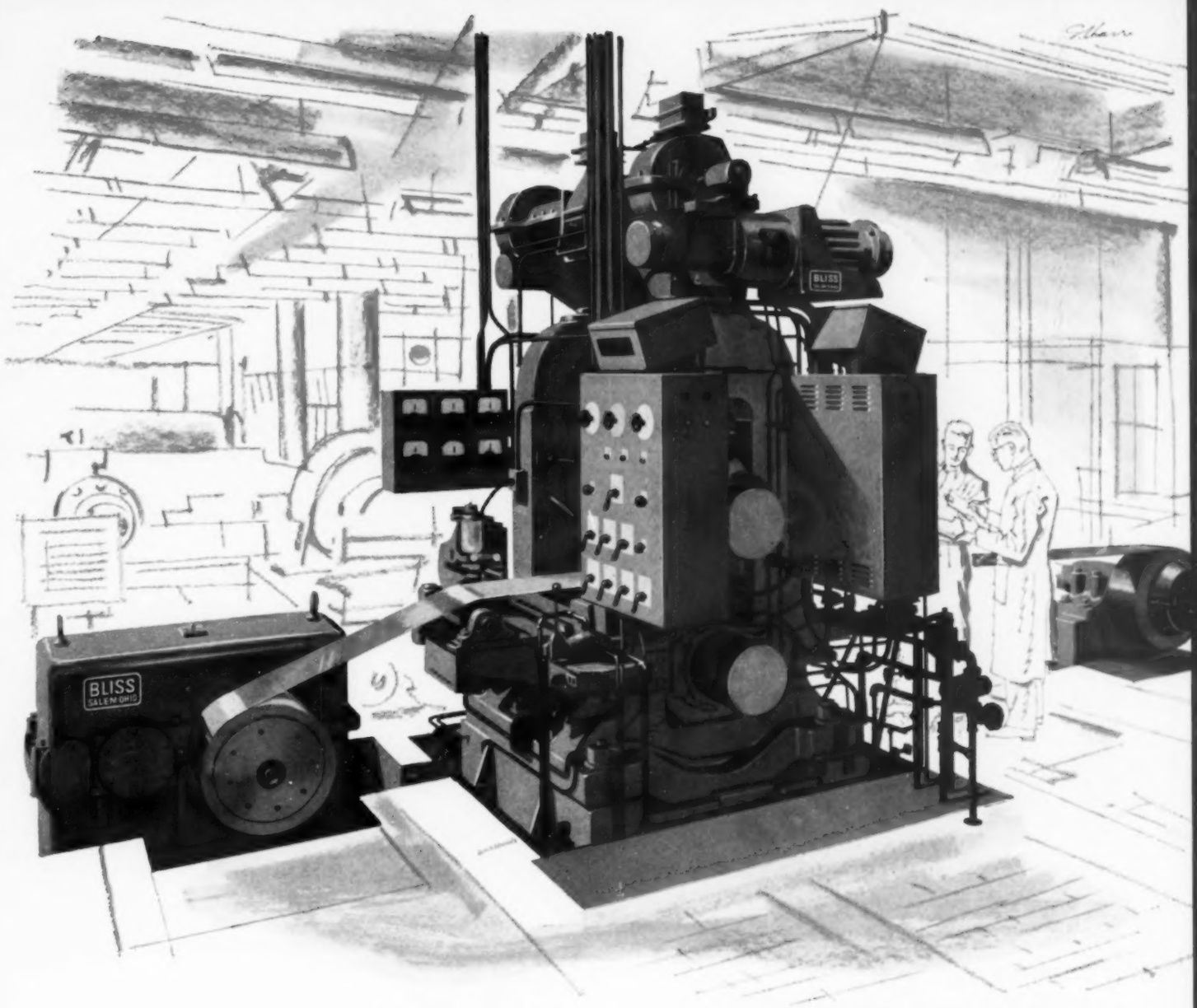
Well aware of the advantages of "controlling" the heat and of tapping at proper temperature—reduction of skulls and scrap, reduced fuel cost, longer stool, mold, and ladle life, etc.—personnel at No. 2 welcome the reliability and ease of maintenance of the L&N equipment. Normally only the quartz tip has to be replaced after each immersion—a simple operation performed on the furnace floor—and the couple is back in service, with no "time out" for cooling required.

Averaging between 90 and 100 readings per day, No. 2 Shop keeps a meticulous record of the performance of each couple and the consumption of expendable parts. As a result, they compile precise figures on the cost per reading—and feel they're getting reliable, significant bath temperature data at minimum expense.

If you'd like full details about the L&N Immersion Thermocouple and Speedomax recorder, request Process Data Sheet 643(1) from our nearest office, or write us at 4942 Stenton Avenue, Philadelphia 44, Pa.

LEEDS & NORTHRUP
Instruments · Automatic Controls · Furnaces



This Bliss 4-high reversing mill is the principal unit in National Cash Register's new cold rolling department.

When does it pay to "roll your own"?

The National Cash Register Company's Dayton, Ohio, plant had a problem. It couldn't always get enough special strip for the stamped parts of its business machines.

National Cash Register solved the problem by deciding to "roll its own"—and then asked Bliss to help work out the equipment it would need. The end result is a complete cold rolling department, designed and built by Bliss. It includes a 4-high 5¾" and 16" by 12" reversing mill, a 14" shear line, and a 12" slitting line.

Today, National Cash Register tailors standard steel strip to the exact thicknesses, widths and lengths it needs. Its new Bliss equipment turns material out fast and economically, and there are no more shortages to plague the plant's press department.

This installation shows how Bliss engineers can solve a customer's problem. To see how Bliss has handled others, write today for a copy of the 60-page Bliss Rolling Mill Brochure, Catalog 40-A. It's yours for the asking.

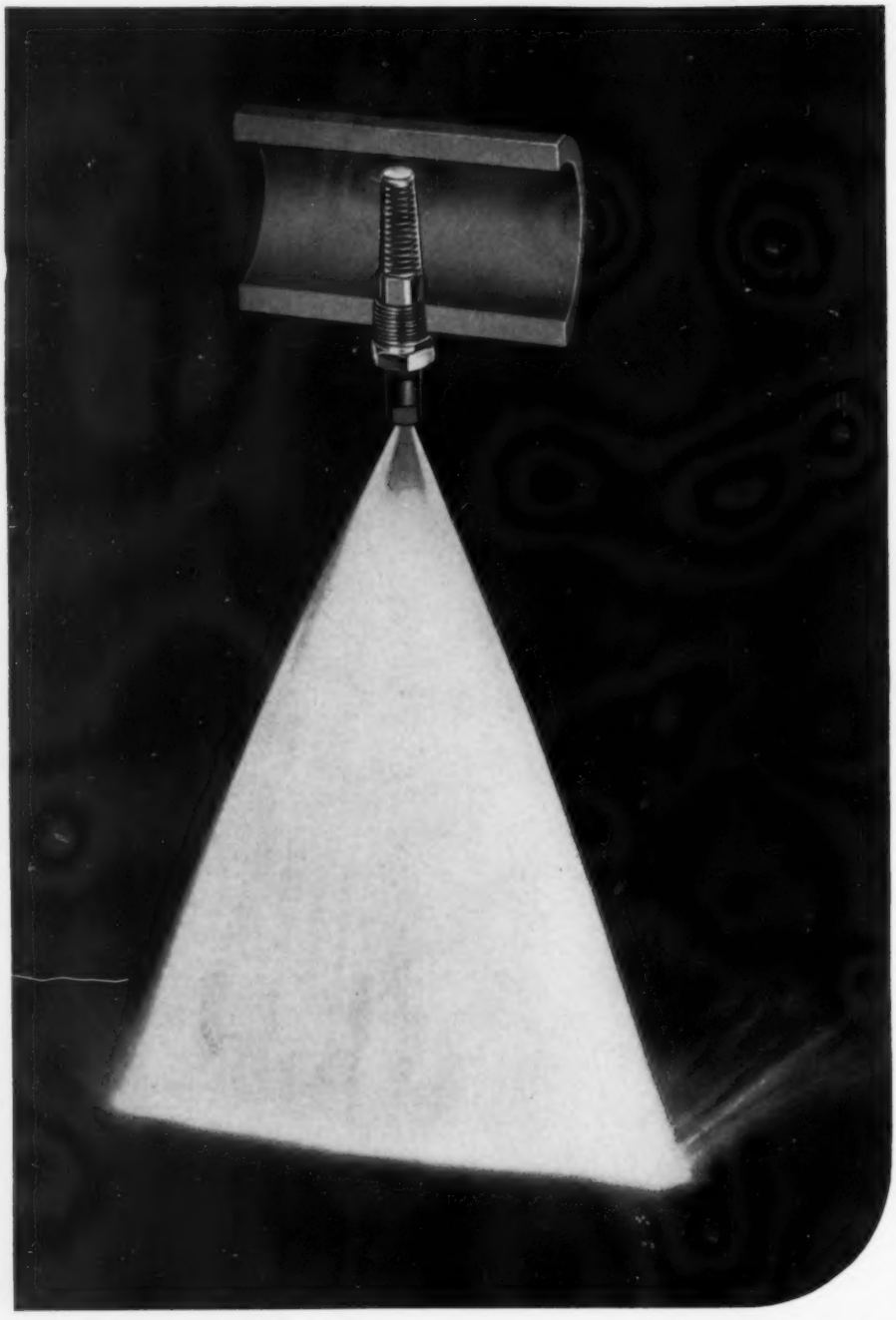
Bliss mill rolls 10"-wide strip down to .009" at speeds up to 400 fpm.

BLISS
SINCE 1857

100 years of making metal work for mankind

E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio



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The thin, concentrated, uniform spray strikes with greatest possible impact for any volume and pressure . . . descales without excessive sheet cooling.

Clogging is practically eliminated by *elliptical*-shaped orifice . . . foreign matter goes right through.

CHOICE OF SIZES . . . offered in 16 different capacities . . . for every known descaling use.

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NATIONAL CARBON COMPANY'S

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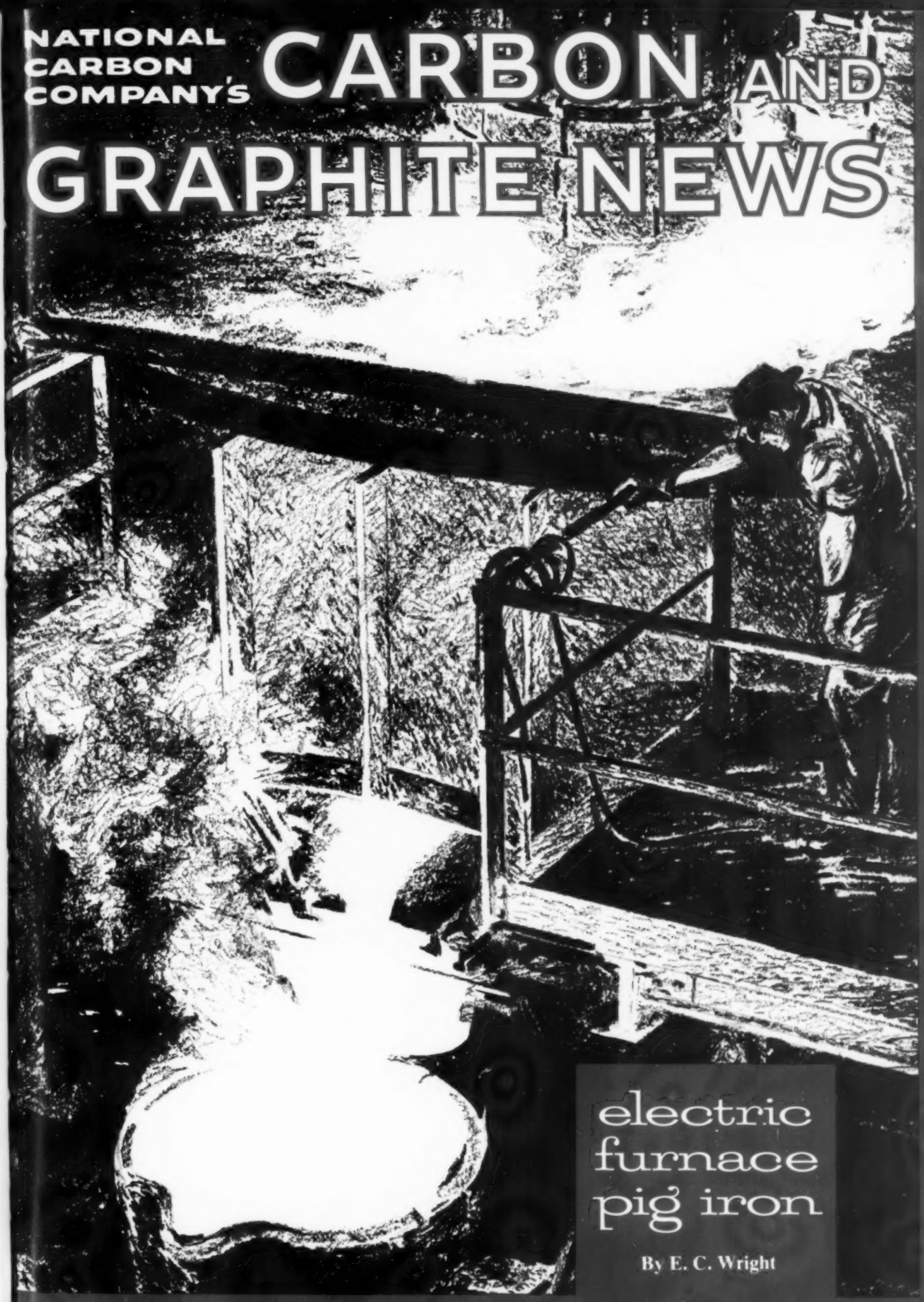
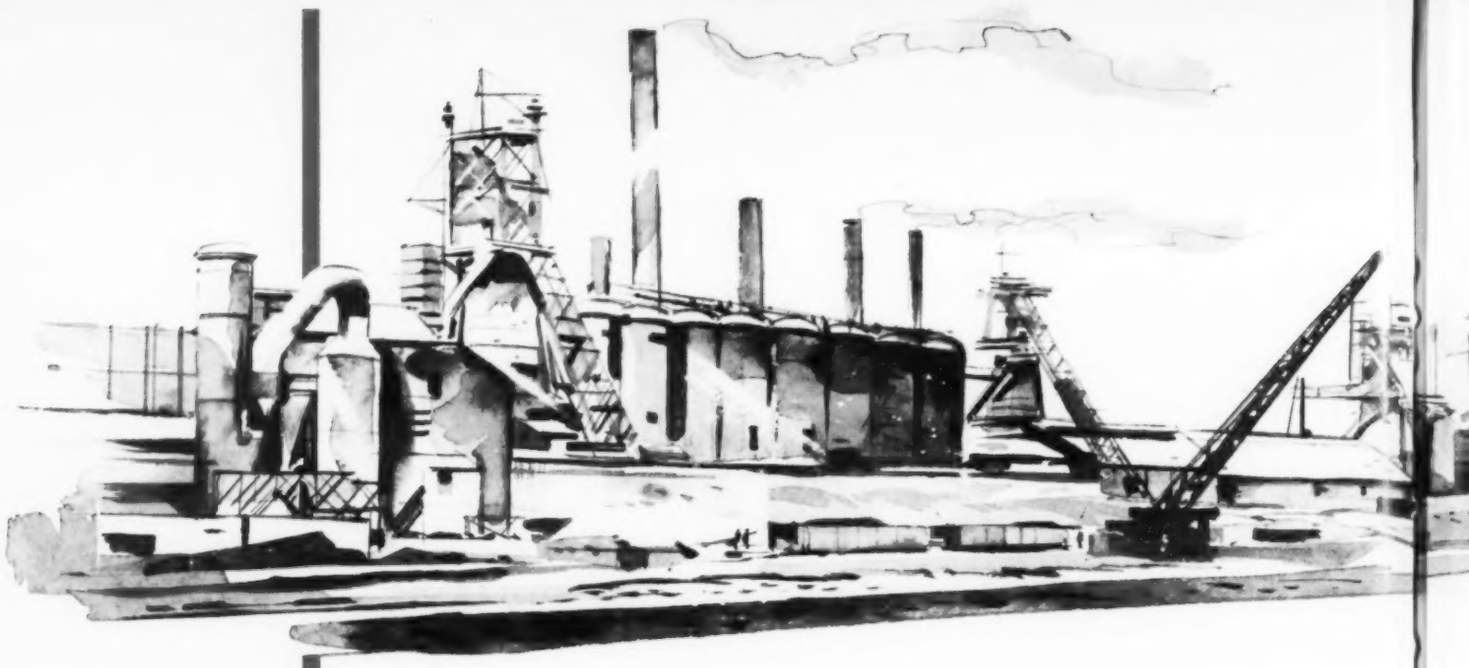


electric furnace pig iron

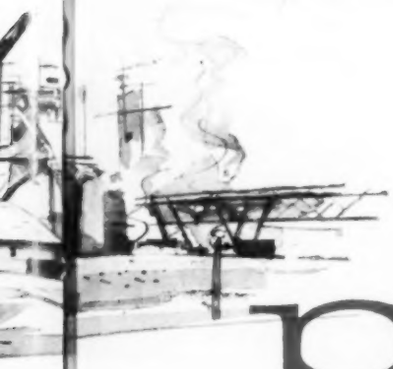
By E. C. Wright



Current Technical and Economical Factors Affecting the Steelmaking Process

- Great increases in freight rates which affect the cost of assembling raw materials.
- Large increases in cost of mining coal and ore.
- High cost of steel scrap.
- Use of cheap oxygen for desiliconizing hot metal for open hearth or electric furnaces.
- Large increases in the use of high grade (over 60% Fe) imported iron ores.
- Use of concentrated magnetite ores which are upgraded to over 60% Fe.
- Complete pre-preparation of blast furnace charge involving accurate sizing of coke, stone, and ore particles including sintered or pelletized iron ore concentrates and complete elimination of all fines from the charge.
- Use of pre-reduced iron ore for electric furnace pig iron smelting at significantly lower power inputs than prevail abroad.

electric furnace pig iron



By E. C. Wright

Head, Department of Metallurgical Engineering
University of Alabama
University, Alabama

Many new technical and economic factors have developed in the past five years which may have an important bearing upon determining the best process to use for making steel at various locations in the United States. Some of the most important of these are cost factors—items such as substantial freight rate increases affecting the cost of assembling raw materials, high cost for steel scrap, sizeable increases in mining costs for coal and ore and the use of cheap oxygen in desiliconizing hot metal for open hearth or electric furnaces. Other important factors are technological in nature. Typical items in this category involve the use of concentrated magnetic ores upgraded to over 60% Fe, large increases in use of high grade (over 60% Fe) imported iron ores, and the use of pre-reduced iron ore for electric furnace pig iron smelting at significantly lower power inputs than prevail abroad. Also, the complete pre-preparation of blast furnace charge involving accurate sizing of coke, stone, and ore particles including sintered or pelletized iron ore concentrates and complete elimination of all fines from the charge.

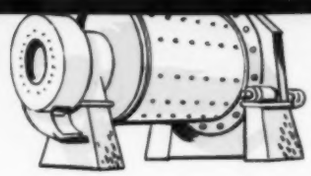
Two Important Results

At the present time the impact of these developments seems to indicate two important results:

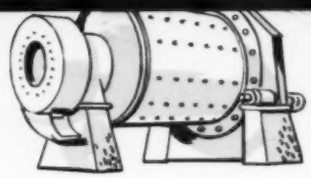
(1) The increased use of higher grade ores or concentrates and fully prepared uniform blast furnace burden will obviously increase blast furnace output per day, decrease coke rate, flux requirements, slag volume, capital charges and overhead on the cost of producing hot metal. These factors will decrease the cost of hot metal based on present costs of raw materials and will greatly benefit fully integrated plants which have ample blast furnace capacity. If these conditions prevail, the future expansion of steel output will be based on increases in blast furnace capacity and greater use of hot metal as compared to cold scrap. Technical improvements indicate such a conclusion but the economics of the relative cost of steel scrap and iron ore will determine the outcome at any given period. Decreasing melt time by means of faster charging, higher blast furnace hot metal charges, desiliconizing blast furnace hot metal or blowing the bath with oxygen at integrated plants will reduce the cost above material as most of the items included in these costs represent an hourly cost which is inversely proportional to the rate of production. The fully integrated plant will thus benefit by new practices in both the blast furnace and open hearth or electric furnace stages and this will increase the favorable cost differential over the cold metal melt shops as long as steel scrap remains over $40 per net ton.

(2) Steel production from cold steel scrap melts at non-integrated open hearth or electric furnace plants

Five Basic Steps of Direct Reduction by Electrics



GRINDER



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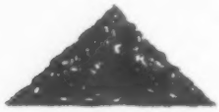


ORE

COAL

will be more costly than charges containing over 40% hot metal whenever the price of scrap is over $40 per net ton. The 1956 Directory of the Iron & Steel Institute showed about 73 electric furnaces of 30 to 150 ton capacity at non-integrated plants where no hot metal is available. At the Electric Steel Conference at Chicago in December, 1956, there was much discussion of the high cost scrap problem among non-integrated electric steel producers and four papers were presented which described the substitution of other iron bearing materials for cold steel scrap. At that time, the Iron Age composite price was $59 per net ton. Some of the papers discussed the direct reduction of high grade iron ores by the electric furnace method, hydrogen reduced iron (H-iron), Swedish sponge iron, additions of ordinary hot metal, and/or the use of desiliconized hot metal as substitutes for all or part of the steel scrap in the charge. Electric furnace direct reduction is an economical method of supplementing blast furnace hot metal at integrated plants, and is also an economical method for making hot metal available to present non-integrated plants.

Direct Reduction By Electrics

The introduction of pelletizing for the processing of fine ores and concentrates has led to some odd new developments. Mineral pellets are made by rolling finely divided minerals with accurate amounts of water in balling drums or rotating discs. Balls or pellets of various sizes are produced in a very wet state and these must be dried and then fired to a high temperature to heat harden the pellets. Usually fine coal (1–2%) is incorporated in the pellet to supply the necessary fuel for the heat hardening process. This yields a strong pellet in the highly oxidized state. Several engineers have found that additions of coal approaching 25% of the pellet weight will not only develop a hard, strong pellet, but also pre-reduce much of the Fe_2O_3 or Fe_3O_4 in the pellet to FeO or metallic iron. Furthermore, hot pre-reduced pellets (above 1600°F) may be discharged directly into a submerged arc electric smelting furnace and produce hot metal directly from the pre-reduced pellets with a great saving in electric power.

Calculations indicate that a 32 ft. diameter furnace, 45 inch pre-baked carbon electrodes, and 20,000 KVA available power will produce 400 tons of hot metal per day at a cost of $45 or less per net ton. Very low sulphur pig iron is made in a basic lined furnace. The equipment needed for such an installation is mainly:

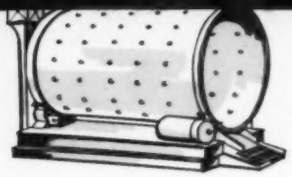
1. Grinding and Blending machinery for mixing the ore, coal and limestone.
2. Pelletizing Equipment.
3. Sintering machine or vertical shaft furnace for the heat hardening and pre-reduction of pellets.
4. Submerged arc smelting furnace for making hot metal.

Economic Advantages

The direct reduction of high grade iron in submerged arc smelting furnaces is widely practiced in several foreign countries where the cost of coal and coke is high. Foreign plant operations consume about 2270 KW hours per net ton. Developments in the United States make it possible to produce electric pig iron at roughly ½ the KWH per ton consumption of foreign plants.

Estimates indicate an investment in the neighborhood of $6,000,000 should cover the installation of a 400 to 500 ton per day unit. Based on 8000 hours per year operating time the investment cost will approximate $40 per annual pig iron ton which is somewhat less than that of a complete blast furnace, coke plant and accessories. It is obvious that as long as steel scrap remains above $45.00 per net ton, the substitution of molten hot metal at $45.00 per ton or less would be an asset to a cold scrap electric furnace plant for either carbon steel or alloy steel heats. The use of high grade foreign ores or concentrates containing over 60% Fe would also lower the cost of this operation by decreasing slag volume, fluxes and power required on the electric furnace. This new process thus suggests a way out of the present economic difficulty which has arisen to plague all cold scrap melting operations as a result of widely fluctuating scrap prices; it also enables a small non-integrated melt shop or foundry to obtain 400 tons per day of molten hot metal without facing the very high investment cost encountered in the construction of a modern blast furnace plant.

Another advantage of this hot metal supply is that it could be cheaply desiliconized with oxygen and



PELLETIZING

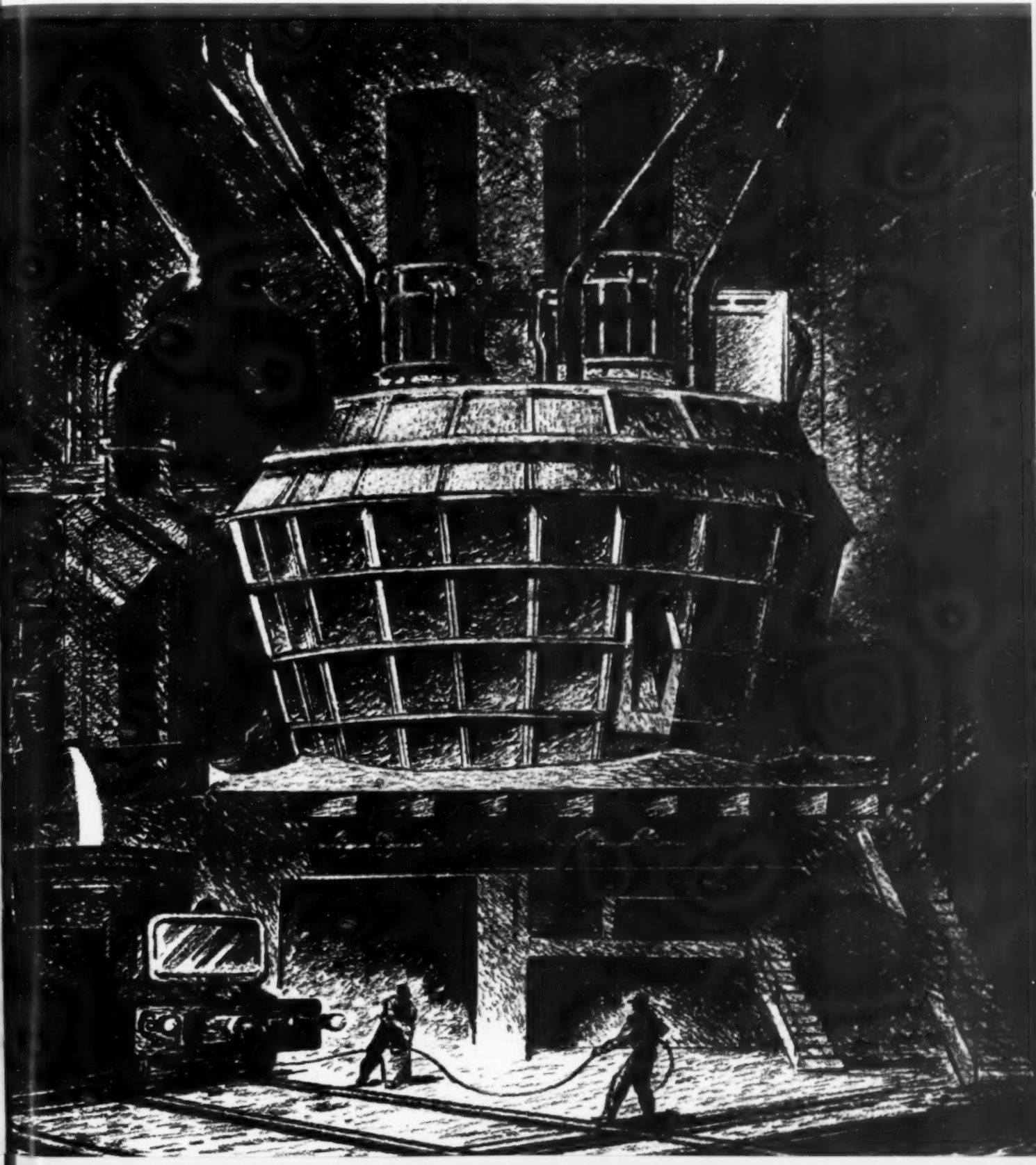
PELLETS

REDUCTION

REDUCED ORE PELLETS

ELECTRIC FURNACE SMELTING

HOT METAL OR PIGS



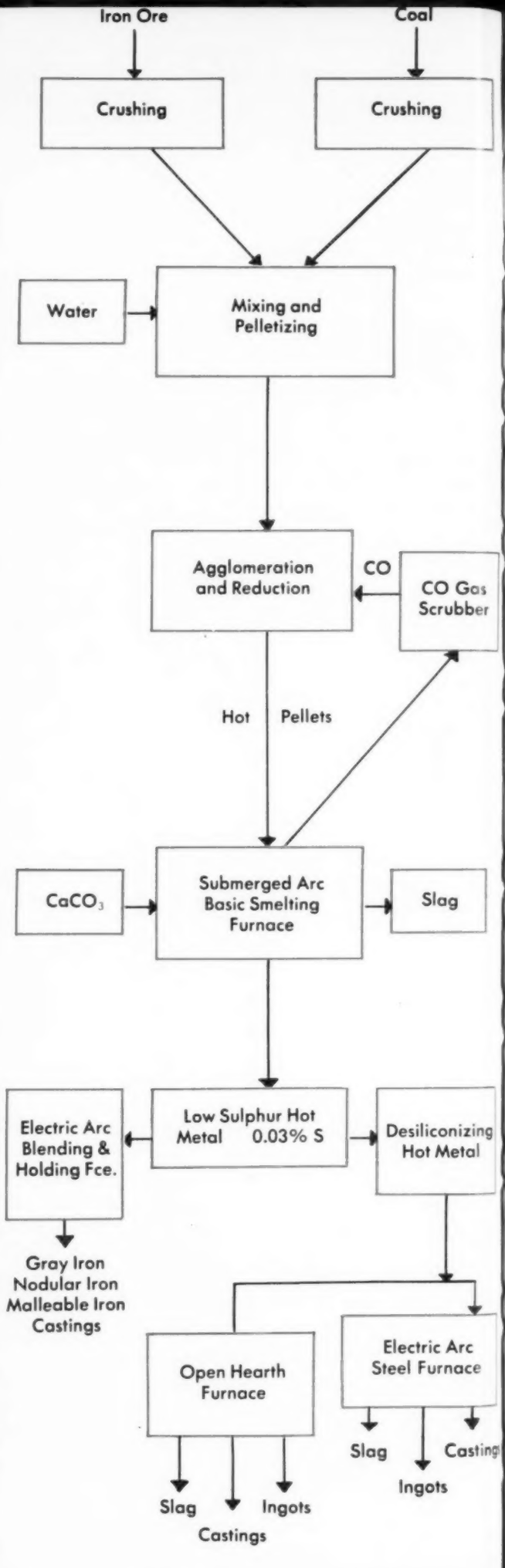
thus make possible production rates in electric steel furnaces of over 40 tons per hour in a 100 ton furnace instead of 20-25 tons per hour now made on cold scrap charges. This would reduce the cost of steel melting by saving power, electrodes, labor, etc. In addition, electric furnace pig iron can be produced and controlled within very close limits of carbon, silicon and sulphur, which should help to reduce processing costs where these elements must be controlled by present day operations. This over-all per ton saving might well be credited to the amortization of the hot metal producing unit.

The installation of an electric arc smelting plant using a pre-reduced iron ore charge should also be of great value to large iron and steel foundries which consume over 100 tons of cold pig iron per day. Such equipment could produce molten iron of low sulphur content economically, depending on the cost of iron ore at the plant. A large foundry today must pay $60 per net ton for cold pig iron, plus freight and handling charges ($5–$12 per ton), plus about $5 for melting. Therefore, molten iron ready for casting thus costs between $70–$75 per net ton. Hence an electric furnace pig iron installation would seem to be very attractive in many large foundries in view of the low cost of $45.00 per ton or less. The low sulphur iron made in this basic furnace is also of great advantage for iron castings, particularly the new ductile cast iron.

An additional advantage of electric pig iron plants lies in the fact that they can be fairly small or relatively large . . . for example, the extreme versatility of this type of installation permits production of 200 to 400 tons per day from a single unit, and naturally much greater outputs from multi-units. As a matter of fact, a large multi-unit electric furnace plant can be built at a lower capital investment than a multi-unit blast furnace plant of similar capacity. Furthermore, such a multi-unit electric furnace plant will show operating costs comparable to a modern blast furnace plant.

Hydrogen Reduced Iron

Lately there has been considerable discussion of hydrogen reduced iron ore as a substitute for costly steel scrap. At the present time this operation is based on a fluo-solids reduction roast at various temperatures and pressures. Three pilot plants are using different methods of producing the iron; one operation uses pure hydrogen at 400 pounds pressure and conducts the reduction at about 900°F; the second method accomplishes the reduction at about 1300°F and 50 pounds pressure, also using pure hydrogen; and the third method is being studied at atmospheric pressure and the reduction is done at about 1600°F using a reducing gas consisting of carbon monoxide and hydrogen. In all of these schemes the finally



divided ore mineral is exposed to the reducing gas under the conditions listed with the aim of producing a high grade iron powder. The resulting powder is quite pyro-phoric and must be stored in steel containers until cold and then agglomerated or compacted in some manner which will enable it to be handled in melting. Little economic information is available on these tentative processes but one author has estimated that such material may be produced at a cost of $45–$50 per ton with natural gas as a source of hydrogen when the cost of the gas is less than $0.50 per thousand cu. ft.

Sponge Iron

The Scandinavian steel producers have long used sponge iron as a source to substitute for steel scrap and some of the steel plants are producing steel wherein the sponge iron represents 50%–80% of the total metallic charge. It is reported that 130 thousand tons of this material per year are used for steel making in Sweden. Sponge iron is produced in crucibles, in tunnel kilns, and also in Wilberg-Sodarfers vertical furnaces at a cost estimated at $45–$55 per ton. The total iron content of such materials as H-iron and sponge iron is usually 90%–95%. When the cost of steel scrap exceeds $50 a ton these materials which are charged cold into steel melting furnaces would be competitive with steel scrap.

The use of ordinary hot metal in electric arc furnaces has appealed to the electric furnace steel smelters for many years, but it has only occasionally been employed even in integrated steel plants because of the short supply of hot metal for the electric furnace. When hot metal is available in integrated steel plants, it has always been used in the open hearth rather than the electric furnace. Since normal hot metal contains about 4% carbon and 1%–1½% silicon, and since the electric furnace has a reducing atmosphere, much larger charges of iron ore are necessary to oxidize the impurities in hot metal charges. This gives rise to several difficulties such as large slag volume and a tremendous evolution of Co gas from the furnace, and it is probably for these reasons the use of normal hot metal is not employed in the arc furnace. The use of desiliconized hot metal overçomes these difficulties by reducing iron ore lime charges, slag volume, and greatly increasing melting time. If more hot metal could be made available, then it would naturally be used after desiliconizing in electric furnaces at great savings in cost.

Desiliconizing

Work during the past two years has clearly demonstrated that the use of ordinary hot metal can be affected by either blowing oxygen into the bath in the electric steelmaking furnace or treating the hot metal

Look Ahead–
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Gives greatest flexibility–
Makes any steel – any time – from stainless to plain carbon. Handles cold scrap, metallics, hot metal. Starts, stops quickly –gives faster melts.

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Goes up fast–
Capital investment pays off sooner.

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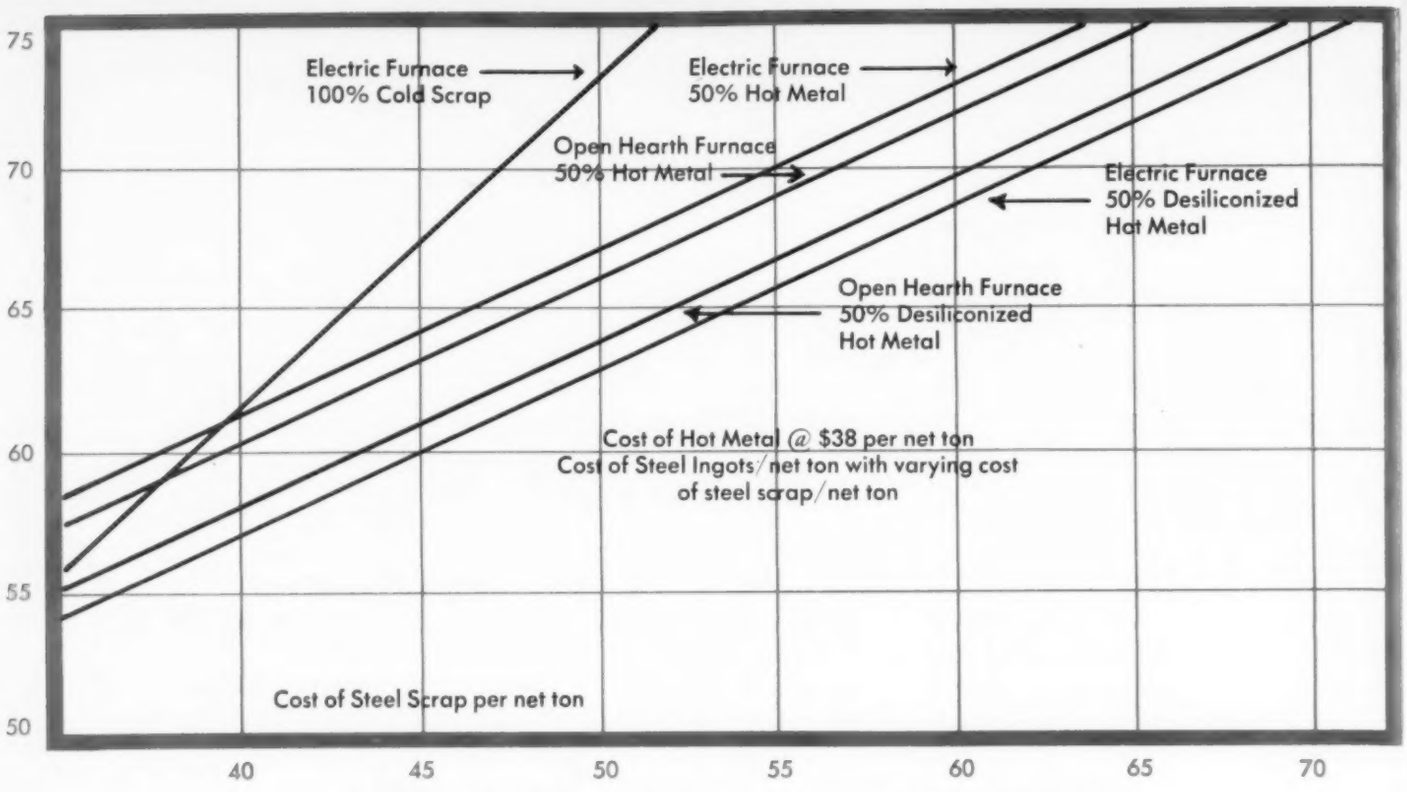

COST OF PRODUCING STEEL INGOTS BY VARIOUS METHODS

with oxygen prior to charging into such a furnace. This operation is termed desiliconizing. The elimination of three-fourths of the carbon in hot metal and all of the silicon so greatly speeds up melting operations in the electric furnace that output is doubled, as the desiliconized hot metal represents a charge of molten steel scrap at a high temperature of about 3000°F. By use of such additions, the output of an electric arc furnace can be doubled by charges of 50%–60% desiliconized hot metal at a cost lower than the cost of melting a 100% cold scrap charge. Some furnaces in Germany are already operating with this practice, usually by blowing oxygen into the arc furnace, but good results have also been obtained on experimental heats where the desiliconizing has been accomplished prior to the charging.

Hot Metal Assures Flexibility

Based on the economic discussions in this article, the influence of widely varying cost of steel scrap on the cost of producing steel ingots by various methods has been calculated and is shown in chart above, which brings out the result. This comparison shows the relation of 100% cold scrap, 50% hot metal, and 50% desiliconized hot metal charges in both open hearth and electric furnaces. In this chart the cost of pig iron is taken at $38 per net ton.

It is thus obvious that an electric steel melting plant which has a source of molten hot metal at $38 –$45 will assure a highly flexible situation which could be varied in relation to the widely different prices for cold scrap occurring from year to year.

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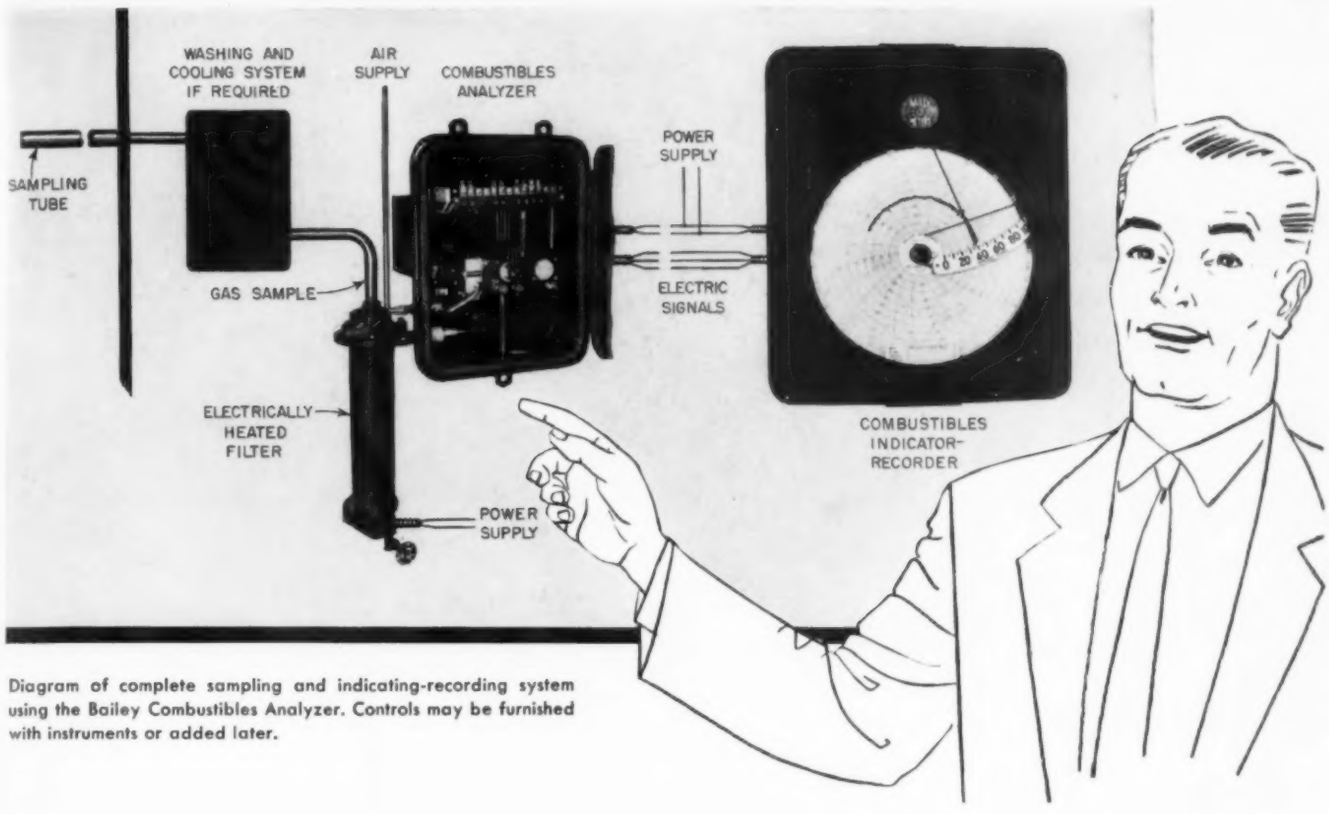

Diagram of complete sampling and indicating-recording system using the Bailey Combustibles Analyzer. Controls may be furnished with instruments or added later.

BAILEY COMBUSTIBLES ANALYZER

improves steel quality, saves gas

Whether you are doing bright annealing, hardening, normalizing or carburizing, keeping a constant watch on your atmospheres with a Bailey Combustibles Analyzer will help you do a better job at lower cost. This instrument provides a continuous measurement of the per cent combustible in the protective atmosphere gasses. It operates a remote electronic receiver for indicating, recording and controlling.

The Bailey Combustibles Analyzer monitors the quality of atmosphere gas. When the quality changes, as shown by changes in the per cent combustibles, the Analyzer operates a pneumatic controller which automatically controls the fuel rate. By maintaining the proper gas-air mixture, the uniformity of the atmosphere—and of the final steel product—is protected.

An important use for the Bailey Analyzer is in furnace purging—necessary to prevent explosion during startup. The instrument tells the operator when the combustibles have been reduced to a point where it is safe to start up the furnace. Without a Bailey Analyzer, purging is usually done strictly on a time basis, a procedure that is wasteful and unsafe.

Put the Bailey Combustibles Analyzer to work as a watchdog and control on your atmosphere generators and heat treating furnaces. It is the one way you can be sure you are maintaining the atmospheres specified by metallurgists for your processes.

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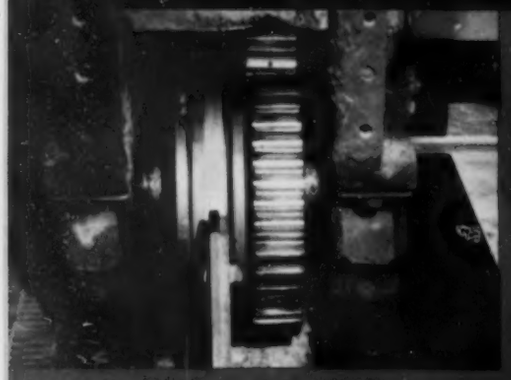
INSTRUMENTS AND CONTROLS FOR POWER AND PROCESS

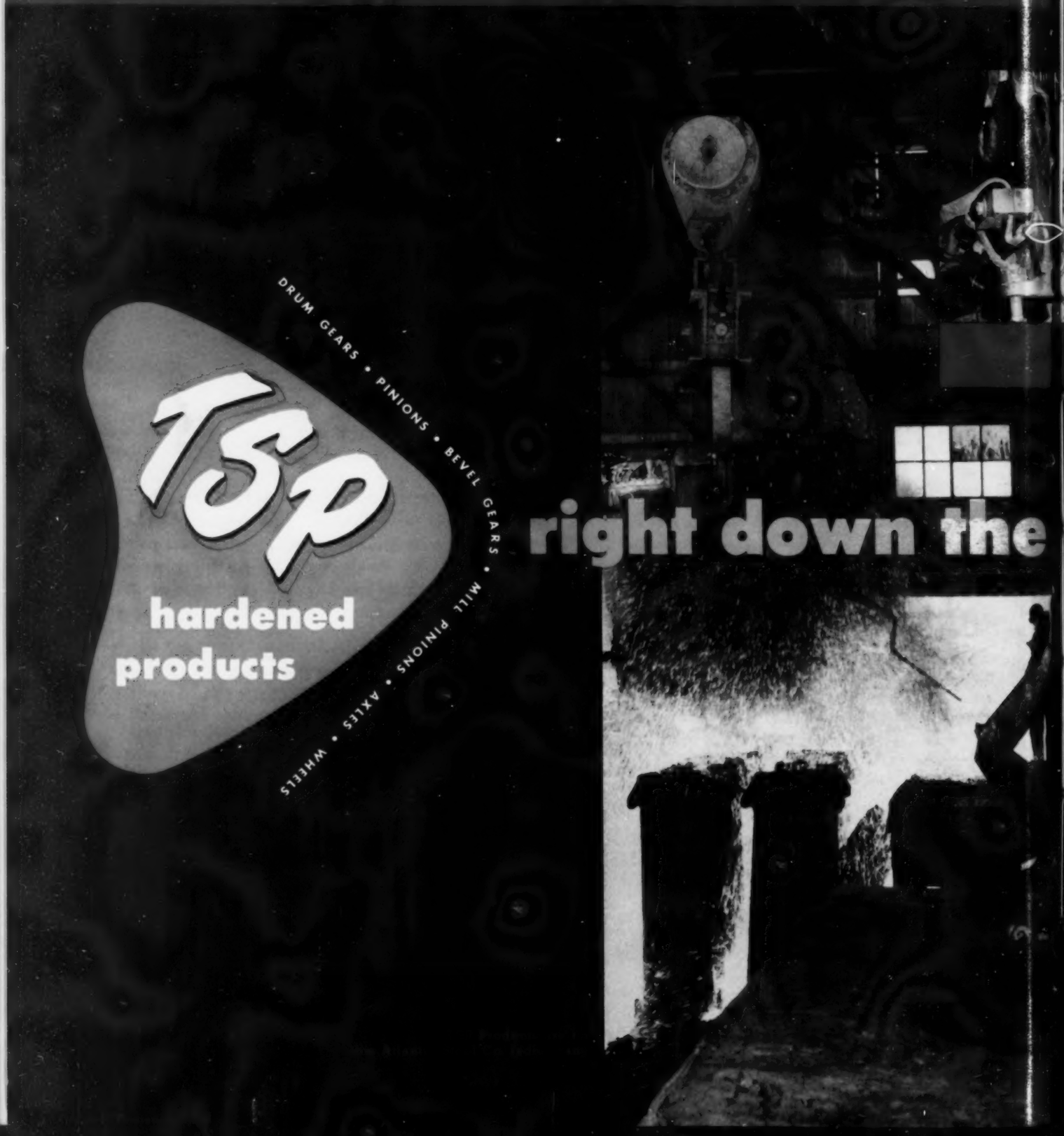
BAILEY METHOD BUILDING BLOCK



TSP Gears and Track Wheels

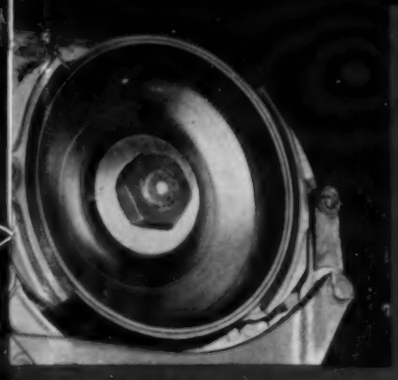
TSP Wheels, Axles

TSP Gear and Wheel for cranes



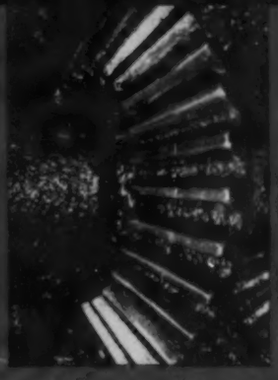
TSP Bevel Gears on blooming mill tables

TSP Pinion and Drum Gear for crane trolleys

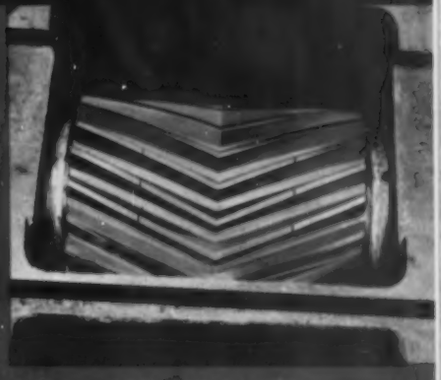


TSP Brake Wheel for cranes

TSP Charging Machine Wheels



TSP Table Line Shaft Gearing



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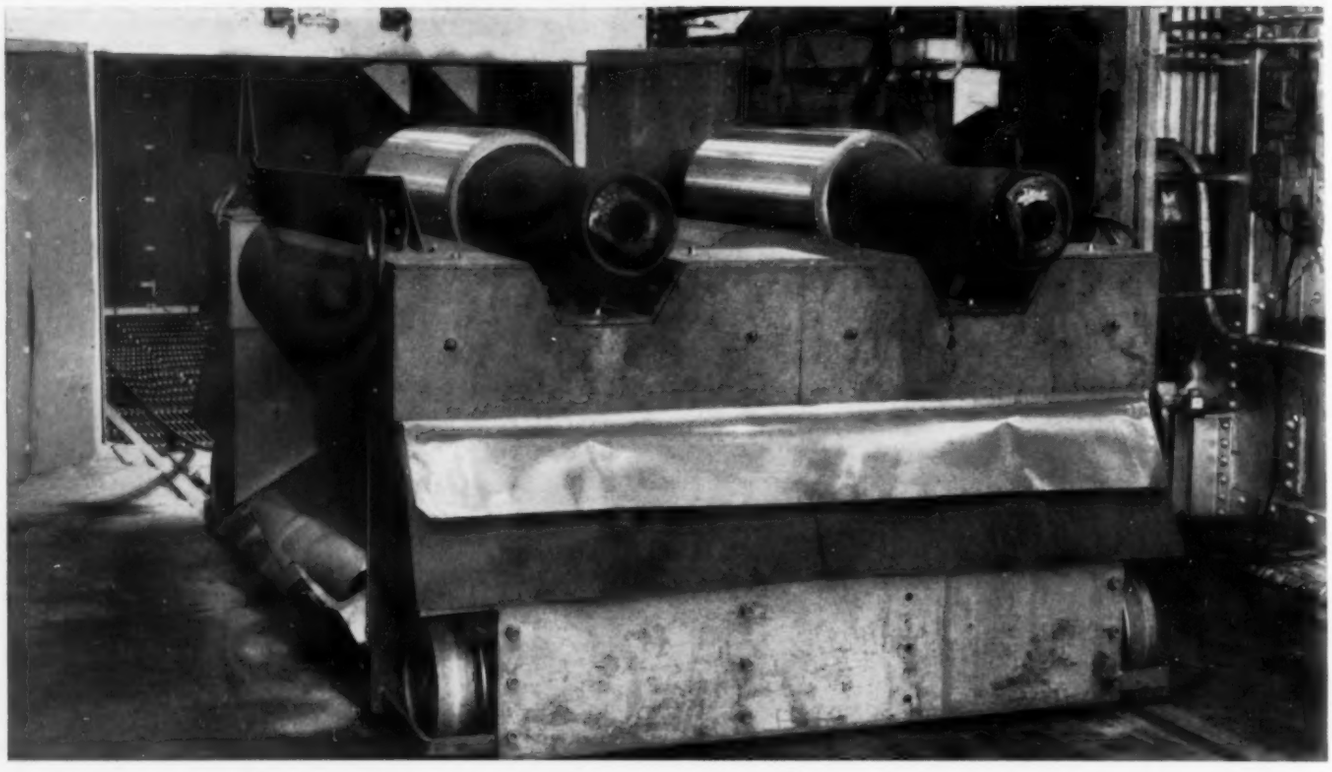

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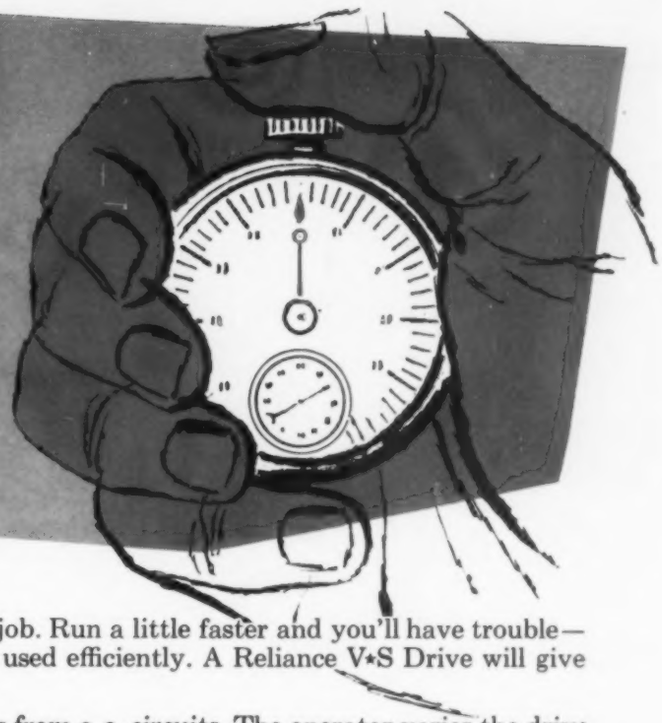

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Reliance V★S is an all-electric drive that operates from a-c. circuits. The operator varies the drive motor rpm. to set up the ideal speed for every job. With no rigid set of gear ratios with a limiting number of speeds, he has an infinite selection of rpm.'s from a wide flexible band of operating speeds.

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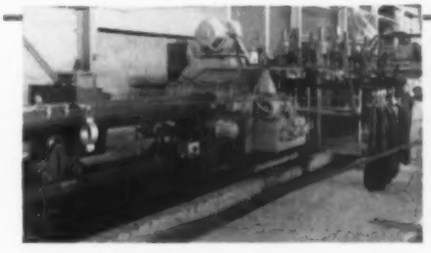
In order to maintain a uniform production rate of 80 tons per hour with varying sizes of pipe, this pipe mill must change its line speed from 30 ft. per minute to 80 ft. per minute to compensate for differing gauges of steel. A 500 hp. multi-motor V★S Drive does the job.



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In order to properly size differing types of cotton cloth, the textile slasher must operate at line speeds varying from 28 yds. per minute to 225 yds. per minute. A 25 hp. V★S Drive does the job.

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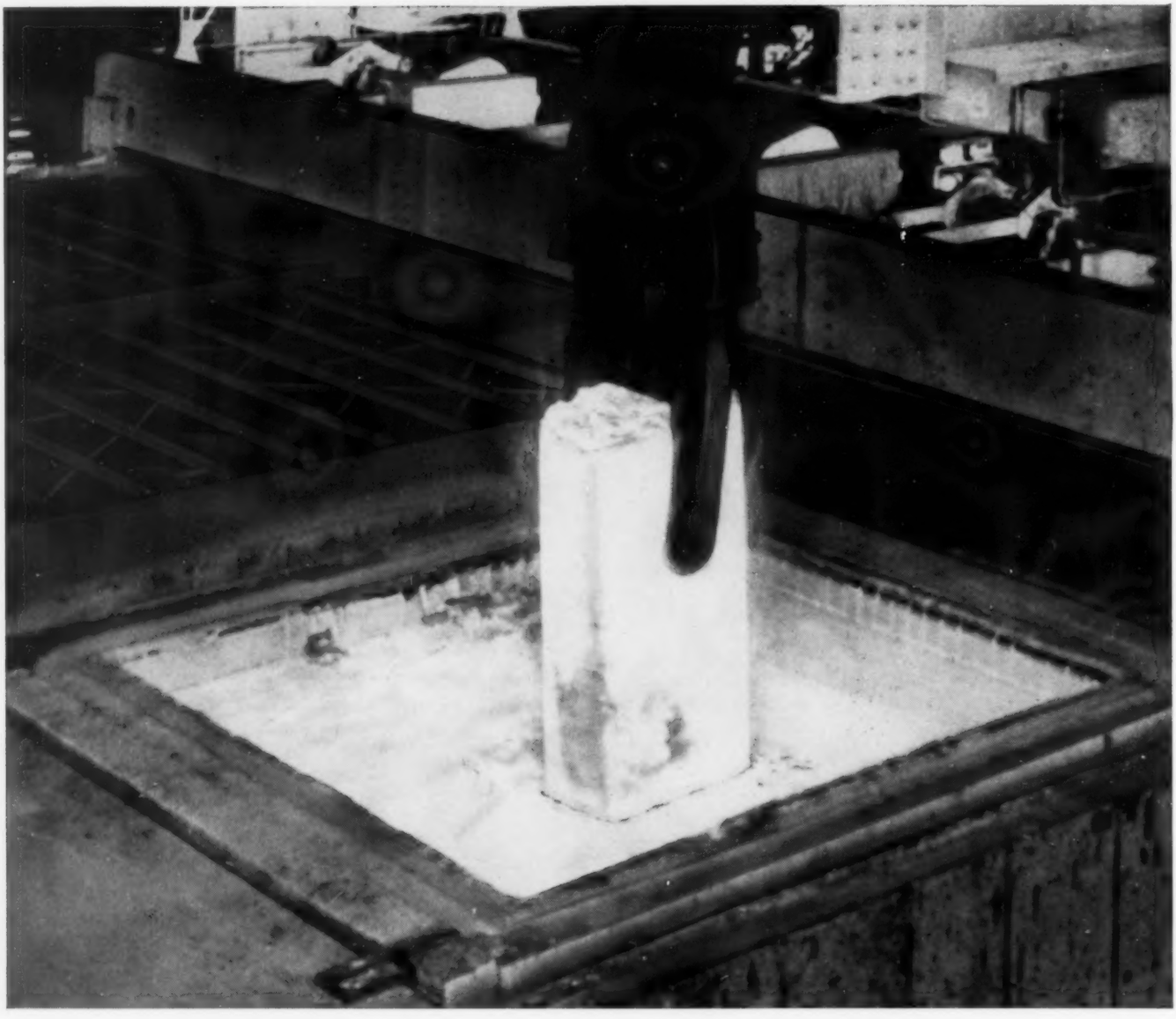


Hagan soaking pit controls

FAST AND EASY INSTALLATION

Hagan systems on the 15 soaking pits installed as a part of Pittsburgh Steel's modernization program include combustion and pit pressure controls. These pits normally burn a mixture of coke oven and blast furnace gas, held to 200 Btu's. This comparatively low Btu content promotes good pit circulation and even heating during the soaking phase.

Oil is available as an alternate fuel, and the Hagan system is so arranged that when oil is fired, the oil flow transmitter impresses a low differential pneumatic signal (same range as gas flow differential) on the fuel/air ratio control and on the fuel/air meter.

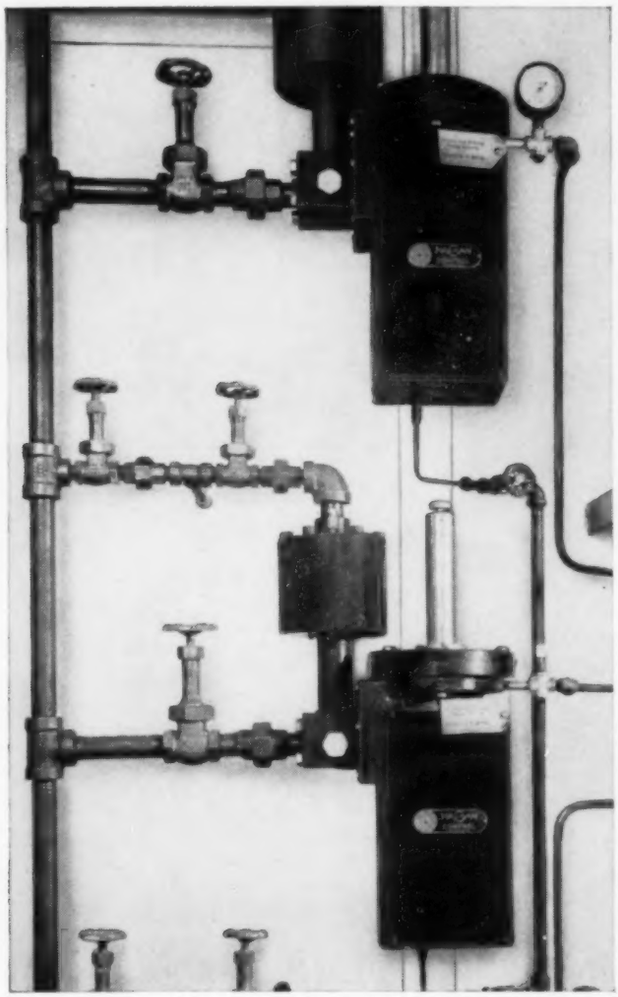
The gas mixing station employs Hagan pressure and ratio controllers to maintain mixed gas header pressure by admitting the two gases in correct proportion.

These systems were put into operation quickly and easily, and plant personnel have found that they stay in calibration and require minimum maintenance.

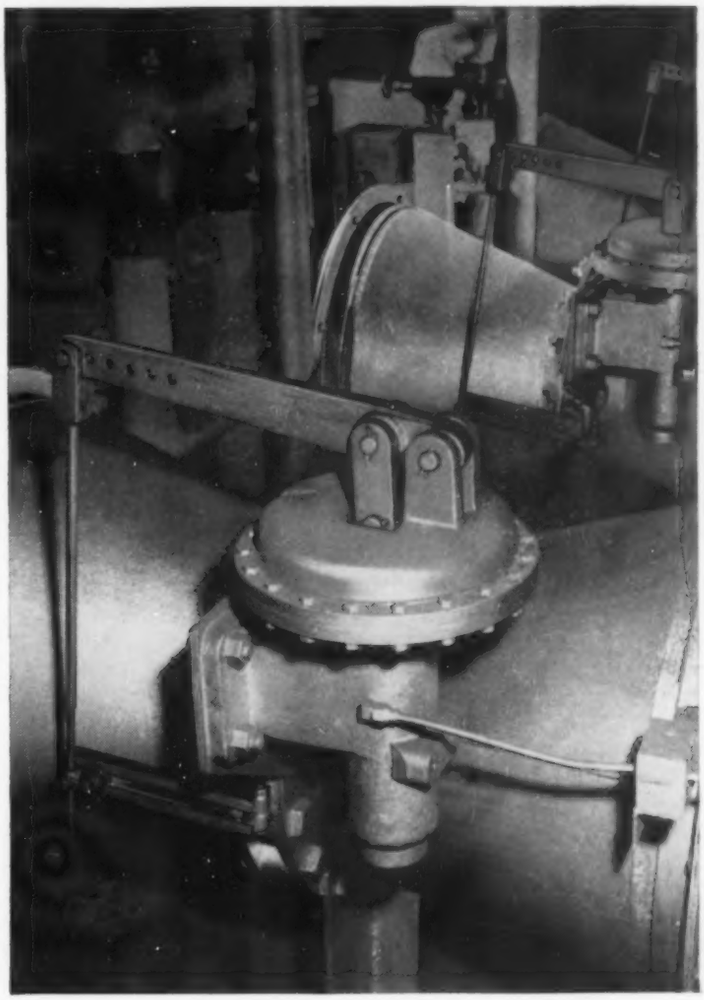
Hagan control systems are also being installed on the enlarged open hearths at Pittsburgh Steel. Fuel/air ratio, furnace pressure control and automatic reversal are among the Hagan automatic control systems to be used on these furnaces.

Hagan systems for soaking pits, blast furnaces, open hearth and heat treating furnaces have established a reputation for accuracy, dependability and minimum maintenance. A Hagan engineer will be glad to discuss metallurgical furnace controls in relation to your particular requirements. A letter or phone call to the address below will receive prompt attention.

Hagan Low-Head Transmitters measure oil flow by means of a sharp edge orifice plate. They develop a low head pneumatic signal which is linear with the differential produced by the oil flow. This signal is then transmitted to the fuel/air ratio control. The Hagan Low-Head transmitter is fast and maintains a high degree of accuracy.



Hagan Diaphragm Operators position low friction dampers on the combustion air inlet fans. These operators provide full modulation, and are extremely fast and accurate. Repeatability is excellent, assuring accurate following of signals from fuel/air ratio control. The Hagan Diaphragm Operator is suited for any low friction positioning application where accuracy and speed are needed.



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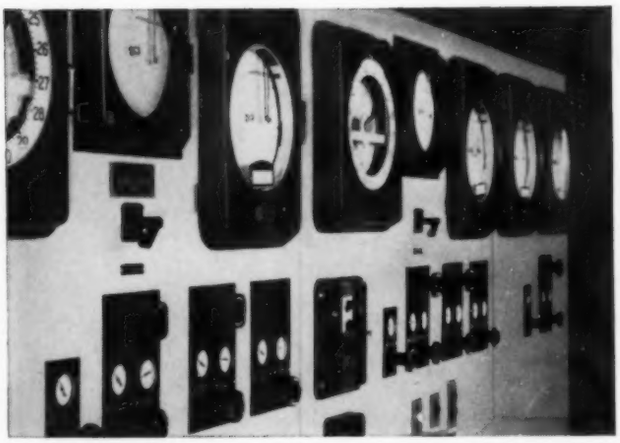

Control Panel shows Hagan Ring Balance meters and Hagan Panel Relays. The Ring Balance meters record fuel/air ratio and pit pressure. Hagan Ring Balance meters are versatile, accurate and dependable instruments. They are calibrated by the dead weight system without disconnecting the meter from the line.

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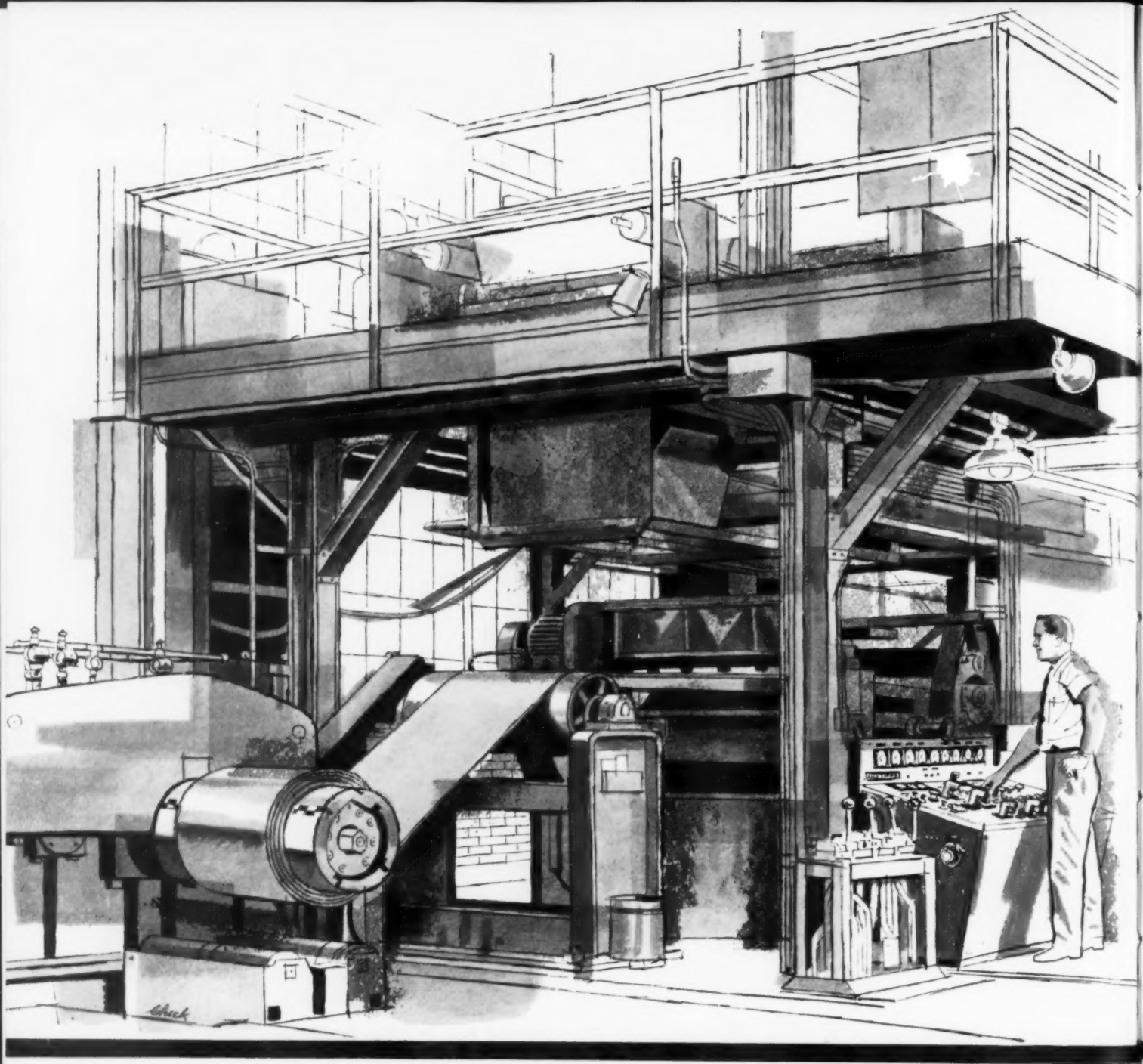

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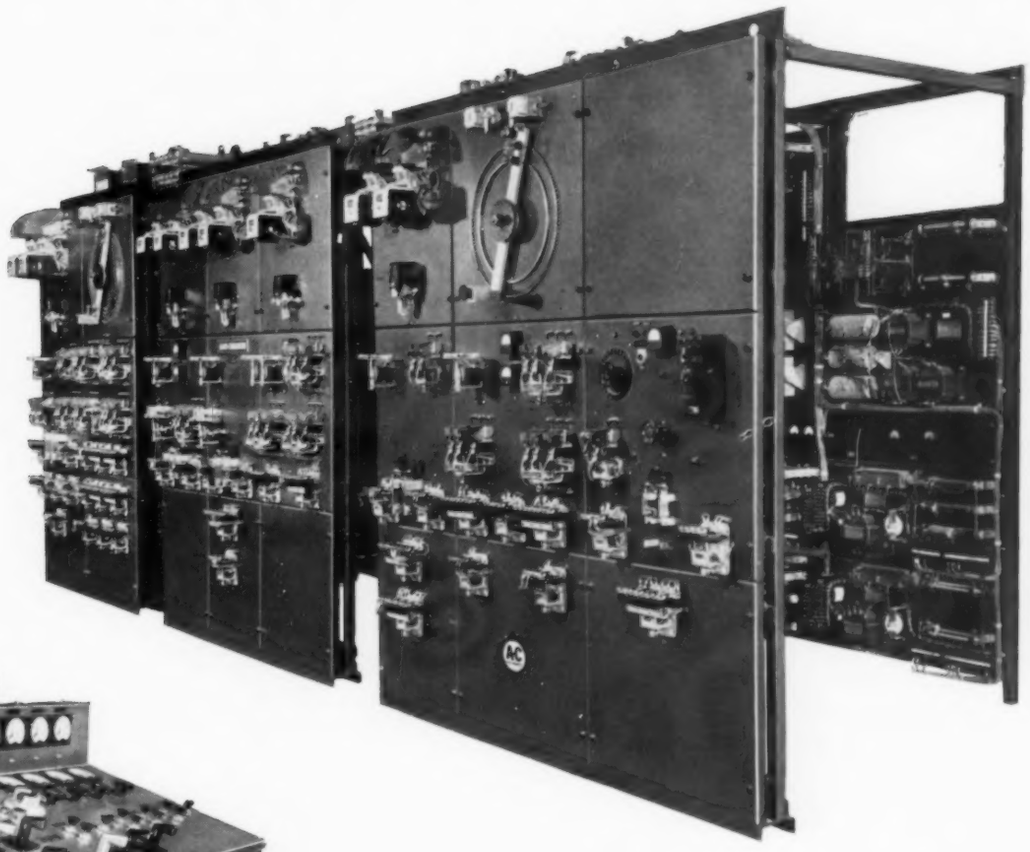

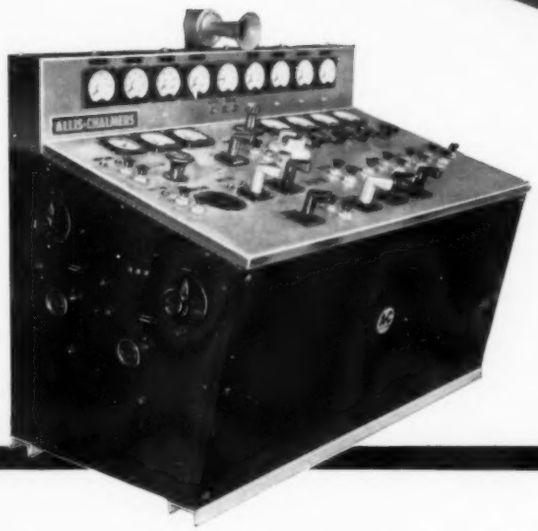

For the annealing line, control by Allis-Chalmers features power-type magnetic amplifier regulators assuring accurate speed control and the most modern tension regulation. Engineered to work with this control are Allis-Chalmers motors and generators.

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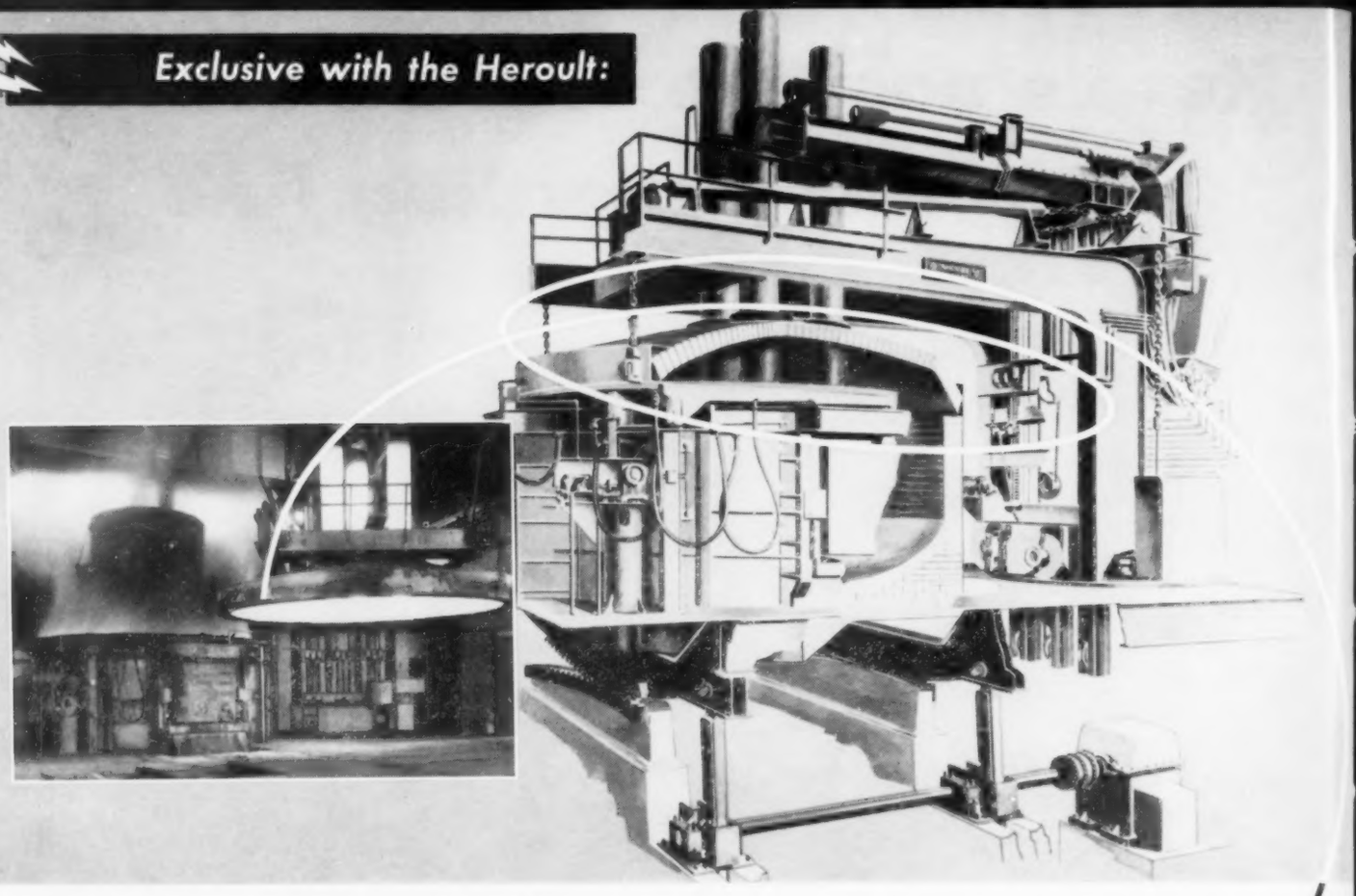

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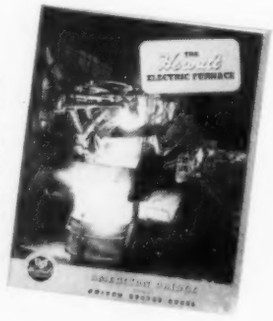

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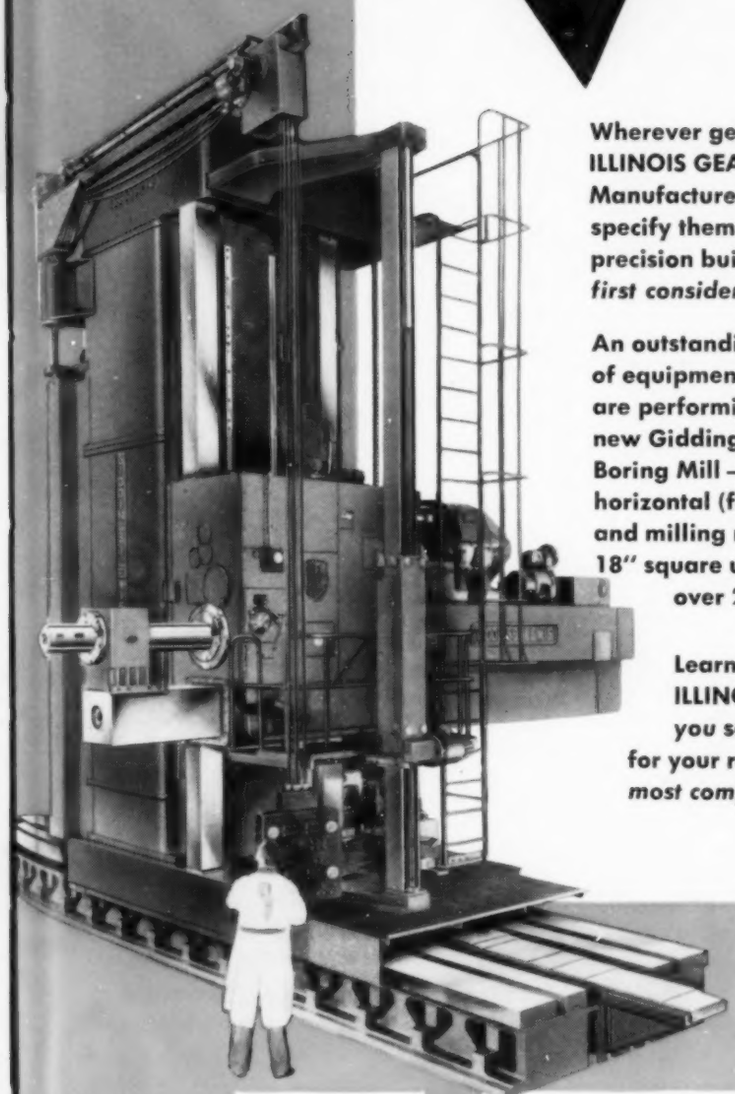

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Drever's reputation is based on performance of units such as this, where quality of product, high production rates, and low maintenance costs are key factors. Plates heat treated in this installation emerge flat and require no further straightening.

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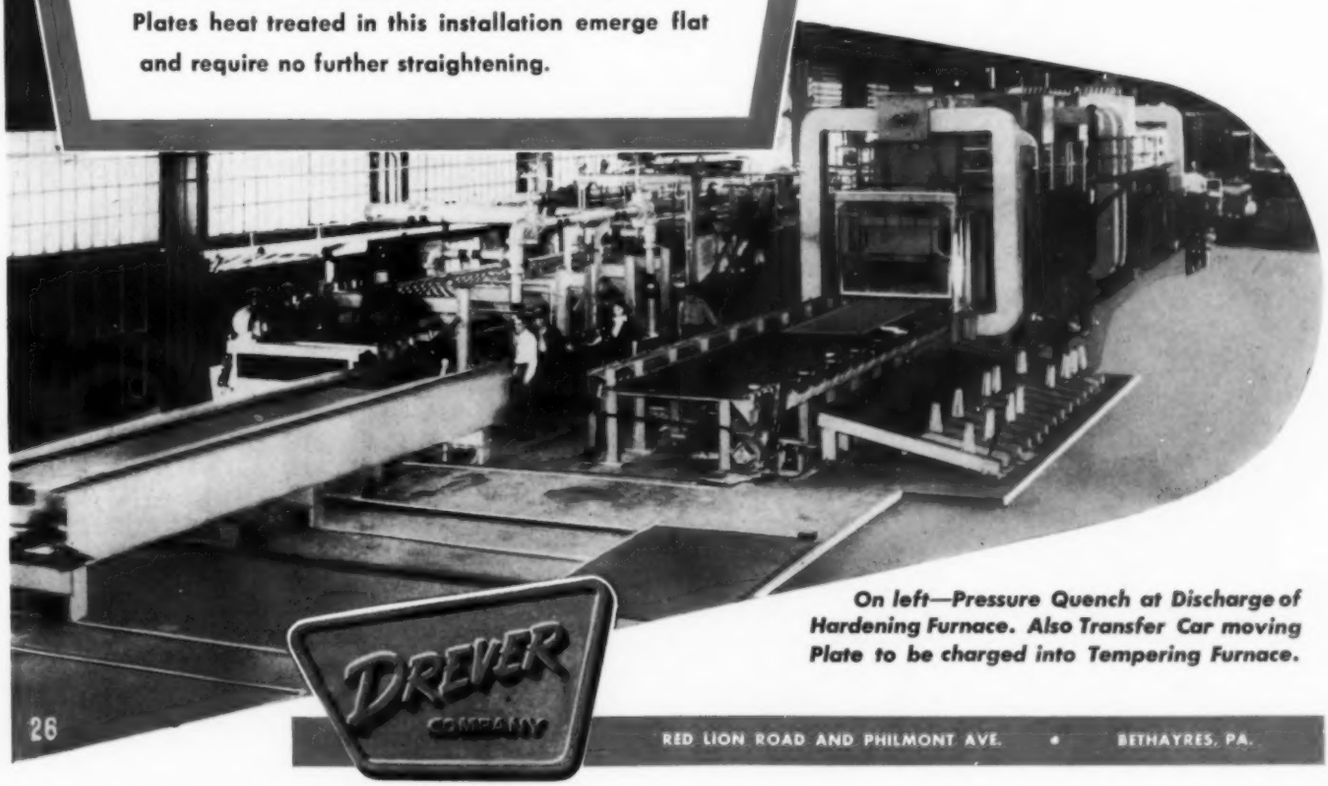

On left—Pressure Quench at Discharge of Hardening Furnace. Also Transfer Car moving Plate to be charged into Tempering Furnace.

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26

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for continuous processing—
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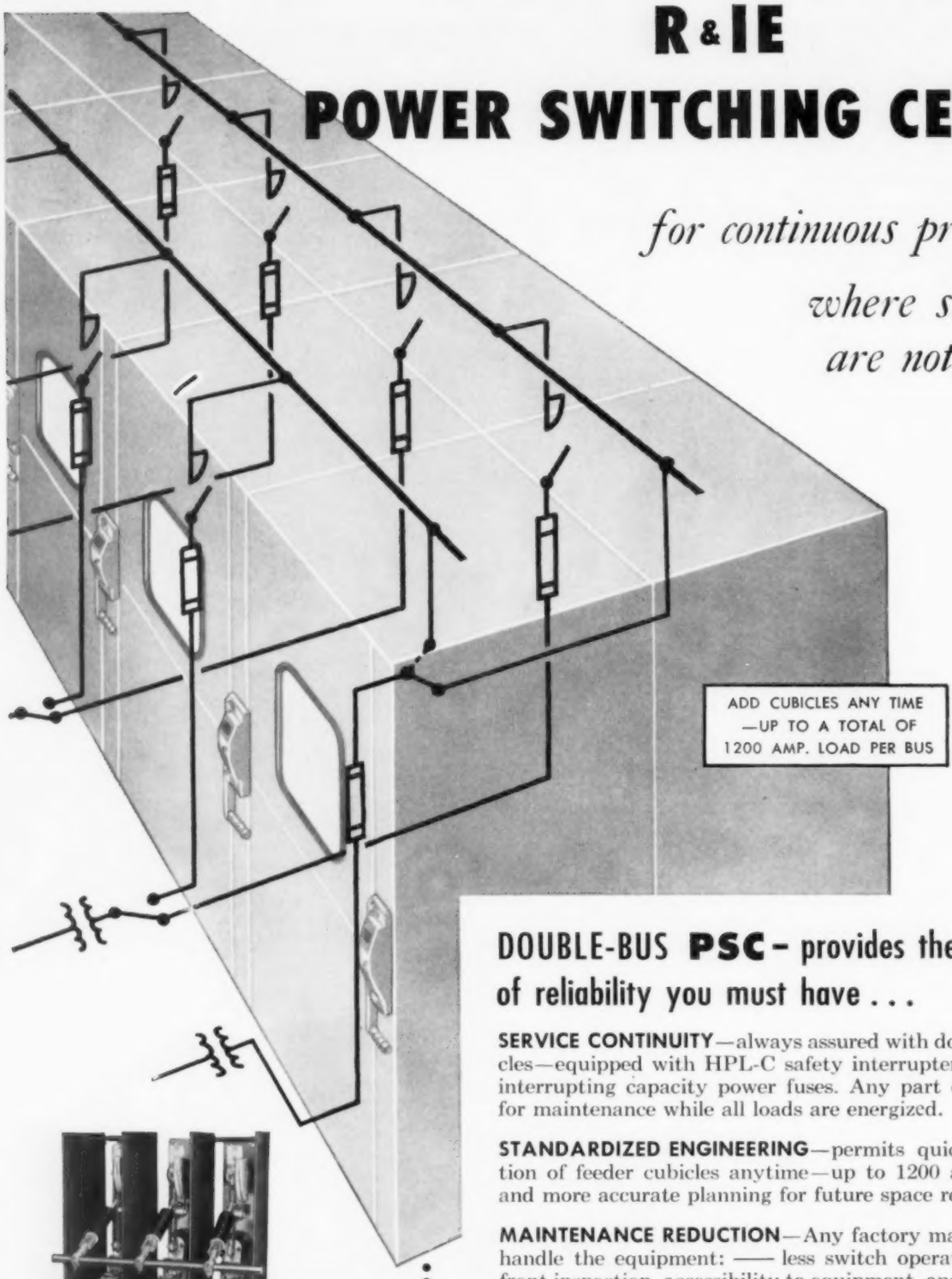

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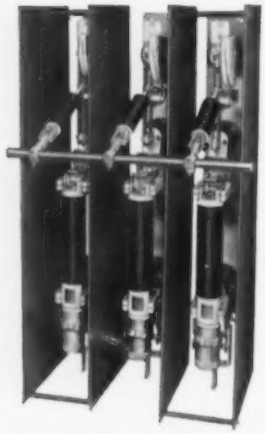

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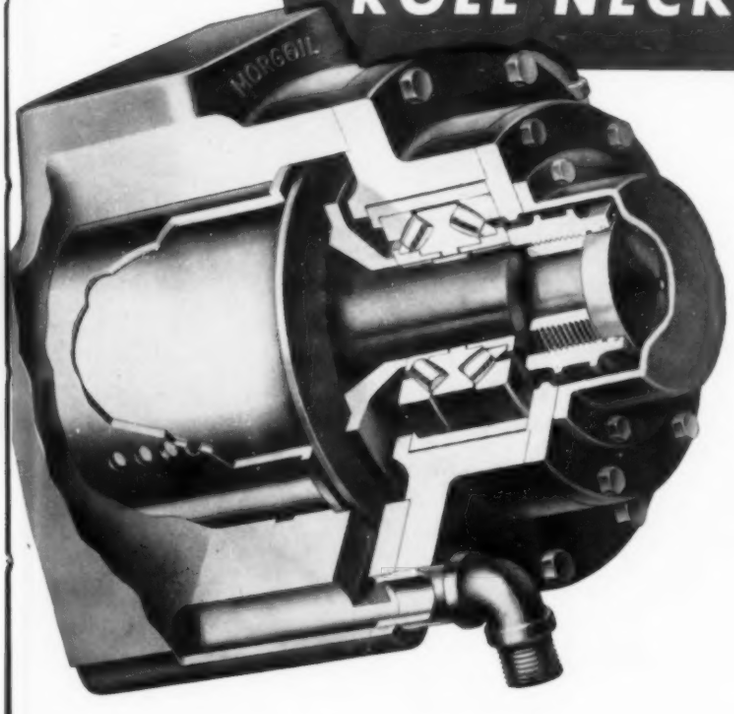

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Superex is easily combined with other insulations such as Johns-Manville Thermobestos®, J-M 85% Magnesia or J-M Insulating Fire Brick.

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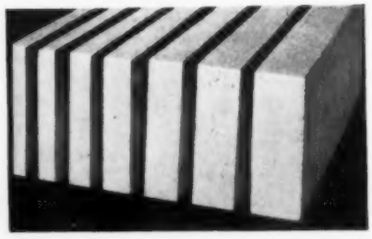

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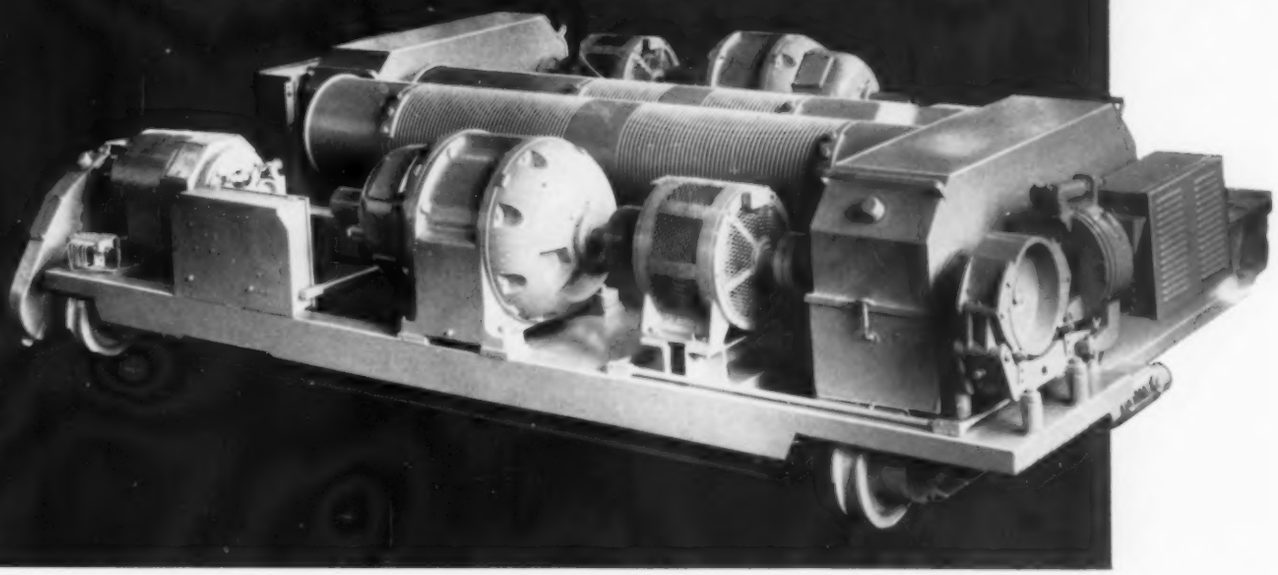
CRANE CONTROL



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EASIER *to operate*

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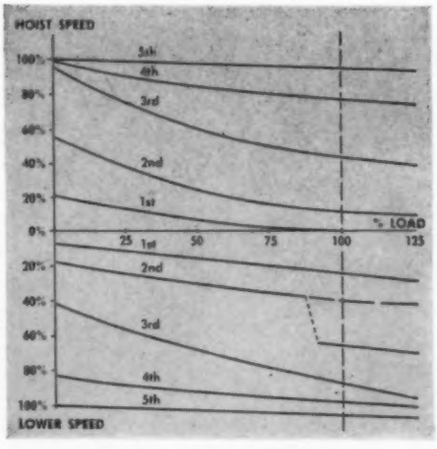

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The low-inertia armature of the 600 Type MC mill motor assures quick response. Outstanding hoist control features an armature shunt point for light hook speed, *plus* an anti-cycling relay to prevent pumping in or out of the limit switch zone. Exclusive Westinghouse self-adjusting d-c magnetic brakes are used to assure positive braking when handling heavy loads. Westinghouse years of experience and engineering leadership have developed the industry's finest and most complete line of motors and controls for heavy-duty mill crane and hoist applications.

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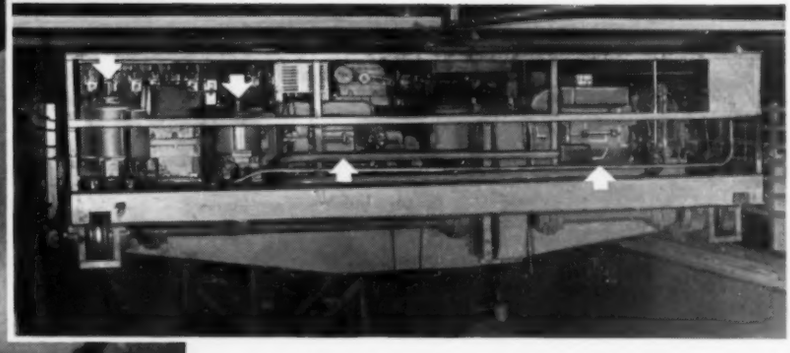
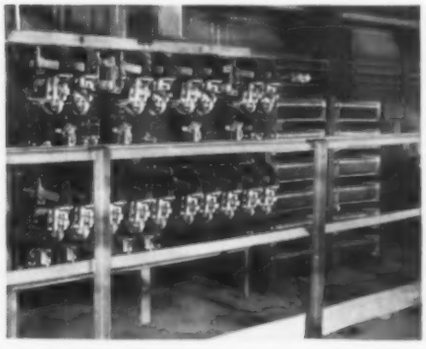


Crane is equipped with Westinghouse d-c mill motors to power bridge and trolley as well as the 20-ton main hoist and auxiliary 5-ton hook. Westinghouse SA brakes are completely self-adjusting—no adjustment or maintenance is ever necessary with wear.



Westinghouse Type M d-c contactors and AZ relays assure millions of trouble-free make-breaks for dependable service in continuous steel mill duty. Self-cleaning, knife-edge bearings guard against dust and dirt.

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Selection and Economy of Equipment for Blooming and Slabbing Mills

By

KURT SCHLESINGER, Sales and Project Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

▲ SINCE World War II, expansion in the steel industry has been a world-wide subject of profound interest. Every nation has the proper desire to improve the standard of living of its people. This ideal is fostered and continued to a large extent by increased industrialization to provide the goods and service people demand.

Inasmuch as steel is a vital component in the manufacture of modern consumers goods and capital equipment for its production and the attendant services such as transportation, etc., steel solicits the interest of all concerned with the study of national economy.

Steel products in their great variety of shapes are not only used for heavy construction such as buildings, bridges, railroads and machinery, but also for a great number of articles in the classification of consumer goods such as automobiles, refrigerators, metal furniture, tin cans, utensils, etc., items all closely associated with a high standard of modern living.

The availability of the essential natural resources, coal, iron ore and limestone, in any area provokes the concept of steel for the support of that area's industry and services. However, to justify their exploitation, these resources must be available and their processing completed at a cost competitive with available sources of supply.

Having the availability of essential raw materials at a proper cost and the market for certain steel products as developed by a thorough market survey, the capacity and type of required steelmaking facilities can be determined.

When considering the size of a new plant, sound business judgment should dictate that it be limited to a minimum plan necessary to enter the field with an economic operation at competitive costs rather than attempt to raise capital immediately for a large plant, even though it is recognized that capital costs per unit of production drop rapidly with the increased size. In other words, a large integrated steel plant can be built for considerable lower capital cost per ton annual ingot capacity than a small one, but there are other objective factors which must be considered in determining plant size.

An ample market will support the production of a great variety of different general types of products, such as bars, structural steel and rails, flat rolled products or seamless tubing.

About thirty years ago, as a result of the development of continuous strip rolling in the U.S.A., which advancement in the rolling mill industry not only improved the quality of products but also reduced prices of such, the demand for flat rolled products increased beyond expectations.

Today, with the ever-increasing consumption of metal goods, from automobiles to home appliances, the demand for sheets and tinplate is continuously increasing.

Let us review briefly the rapid development of the iron and steel industry in the United States during the past three years as reported in the *Iron and Steel Engineer*.

Steel production during 1955 was estimated at 117,036,000 net ingot tons with a finished steel production of approximately 84,717,000 net tons. This com-

. . . . original presentation of this paper was at the "Latin American Meeting of Experts on Steelmaking and Transforming Industries" at Sao Paulo, Brazil, October 17, 1956 . . . . study indicates that rolling mills can be built at investment costs varying from $46 down to $27 per ton of production for plants producing from 50,000 to 900,000 net tons . . . . as plants become larger, total direct and indirect conversion costs vary from about $14.35 down to $8.90 a ton . . . .

pared with a production in 1954 of 88,311,652 net tons and finished production of 63,153,000 net tons.

The steel production in 1955 reports a greater increase than any previous year, superseding even the record production of 111,609,000 net tons in 1953. The continuing demand for steel in 1955, a peace time year, not affected by war, has resulted in many new proposed projects for additional steel producing capacity.

Based on continuous increasing average steel production, it is estimated that in 1970 steel consumption will be 1850 lb per person, compared with 1535 lb in 1955 and 1300 lb in 1950.

Financing of new steel making facilities is one of the most difficult problems steel management faces today. The cost of new steelmaking facilities in the U.S.A. has more than tripled since before World War II from less than $100 per ton to an estimated $300 to $325 per ton.

The sources of financing new steel making facilities or additional rolling mill equipment are through retention of earnings, loans or increased capitalization.

In recognition of the necessity for capital cost analysis in determining the character, size and capacity of steel plant facilities, this paper presents factors and considerations relative to one unit of the plant essential for the production of all rolled products, namely, the primary blooming and slabbing mill.

Blooming and slabbing mills transform ingots into blooms or slabs. We will not consider at this time a study of various finishing mills, in which, in the course of immediate or subsequent processes, the semi-finished product is rolled into finished steel products.

The great range of products possible will influence the types and sizes of blooms and slabs and subsequently the design and degree of mechanization of the finishing mills.

In the following study we intend to analyze the selection and economy of equipment for blooming and slabbing mills only, not considering some other methods of producing blooms and slabs, such as forging, continuous casting, etc.

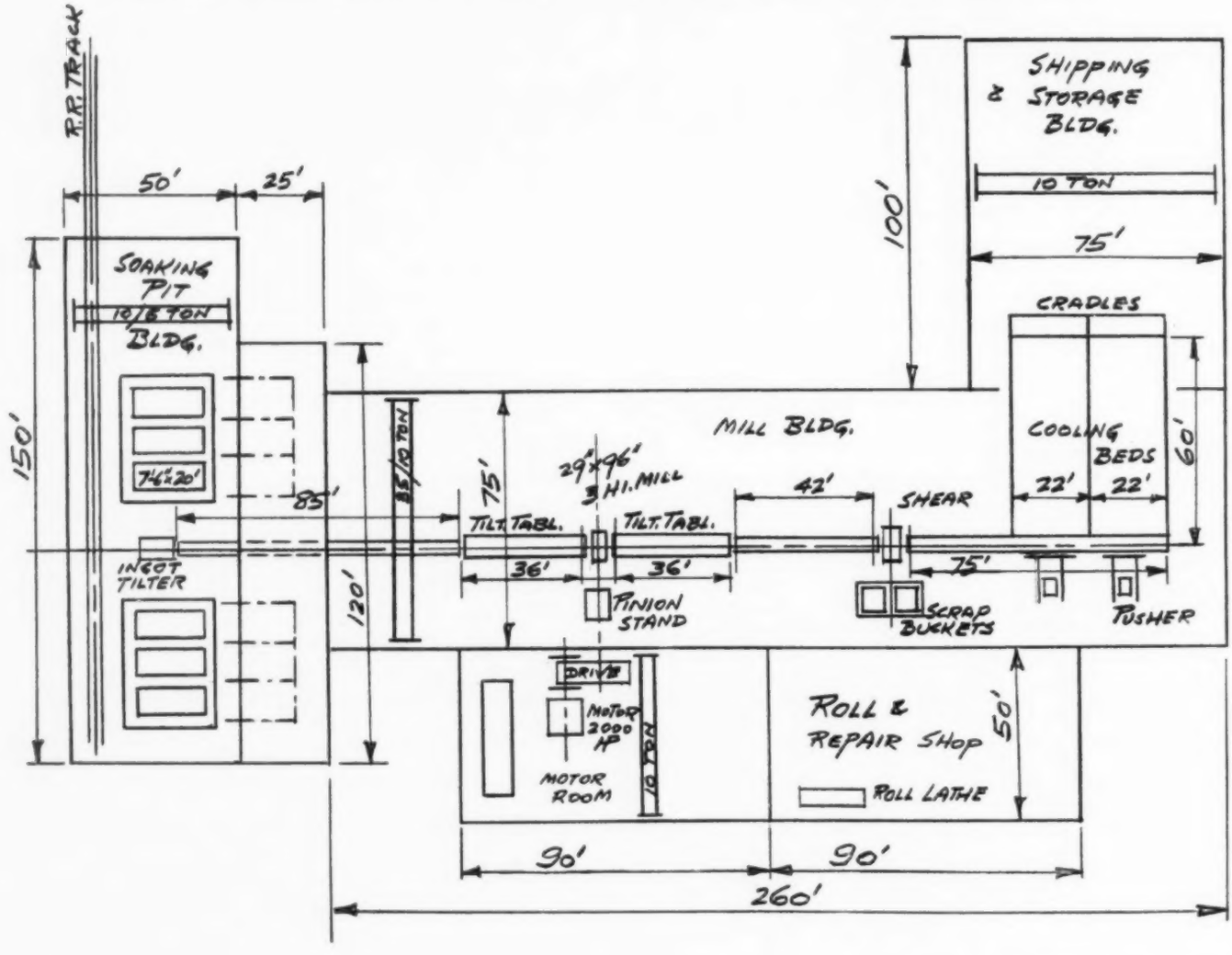
In our case, to best illustrate selection and economy of blooming and slabbing mill installations, we intend to analyze three hypothetical installations of various production capacities.

For the smallest size plant, i.e., with a capacity of 50,000 to 300,000 net tons of ingots per year, a three-high blooming mill installation will be assumed, capable of rolling relatively small ingots into blooms and possibly billets.

For a somewhat larger size plant with 300,000 to 500,000 net tons per year capacity, a medium size, 2-high reversing blooming mill is being considered.

For a large size plant, 500,000 to 1,000,000 net tons per year capacity, a combination slabbing and bloom-

Figure 1 — Schematic arrangement shows a three-high blooming mill typical of unit called Plant A.



ing mill for the rolling of blooms as well as large slabs will be analyzed.

Finally, when analyzing cost, we must recognize the importance of labor-management relations and progress in technology during recent years. This resulted in considerable increased production per manhour due to extensive mechanization and more efficient management controls. Thus, increased efficiency has created in general a long term trend toward lower prices for manufactured goods.

Given herein are actual operating cost figures of three blooming mill projects of different production capacities operating presently in the United States. The figures must be properly re-evaluated and applied to individual market conditions in order to make a preliminary analysis and estimate of the profitability of a proposed project. (All prices listed herein are based on costs during June, 1956.)

The three plants listed herein cannot be compared relative to operating cost since each plant operates with different ingot sizes, utilizing different unit production figures, and must necessarily operate different hours per year to achieve specified tonnages.

PLANT A
THREE-HIGH BLOOMING MILL FOR SMALL PRODUCTION

The primary rolling mill equipment consists of three-high mill stand with three rolls arranged one above the other with tilting tables in front and back of mill stand. See Figures 1 and 2.

Analyzing a hypothetical case, we have selected, for the rolling of 50,000 to 300,000 net tons of ingots per year, a 29 x 96-in. three-high blooming mill driven by 2000-hp, a-c motor, 360-rpm.

This mill is suitable for producing blooms and billets from ingots. The calculations listed below are based on an assumed annual production of 200,000 net tons.

Although the three-high blooming mill with its production limits is generally not acceptable any more for modern mill practices, this type of mill has certain advantages over the two-high reversing mill.

The motive power of a three-high mill is less costly.

Since the rolls revolve continuously in the same direction, a heavy flywheel is applied to the high speed shaft of the reduction gear drive enabling the use of lighter and lower powered motors.

The disadvantages of such a mill installation are its limited flexibility, rolling relatively small size ingots with smaller amount of reduction per pass, and the limited number of sections which can be produced on one set of rolls.

Briefly, such a plant consists of the following equipment:

Item 1: Six soaking pit furnaces—To heat 200,000 net tons of ingots per year uniformly throughout the individual ingots and several ingots in the pits at the same time. Size of each pit is approximately 7 ft 6 in. x 20 ft. Each pit has heating capacity of approximately nine tons per hour at 75 per cent efficiency. Pits to heat rapidly and economically mild steel ingots to 2450 F at closely controlled temperature for best quality and maximum rate of production in rolling. Fuel consumption: Average 750,000 Btu per ton of hot-charged ingots. 1,750,000 Btu per ton for cold-charged ingots. Fuel: Natural gas or oil.

Figure 2 — Mills such as this 29-in. mill produce from 50,000 to 300,000 net tons a year.

Item 2: Stationary ingot tilting pot—This receives hot ingots from soaking pit crane and delivers same to the approach table of the mill.

Item 3: Ingot receiving and mill approach table—Roller bearing equipped and lineshaft driven. Length approximately 85 ft.

Item 4: Front and back mill tilting tables—Each of which is approximately 36 ft long. Table rollers motor-operated. Hydraulic tilting mechanism for each table connected by long lever arms, thus raising and lowering tables in unison. By this means, the material is raised and lowered in proper position before entering the mill.

Item 5: Manipulation—Mounted on the entry tilting table consists of motor-operated side guards with finger lift for turning material.

Item 6: 29 x 96-In. three-high mill stand—Non-reversing, equipped with three grooved rolls, average diameter of roll 29 in., each roll 96 in. long mounted in brass and babbitt bearings. Motor-operated screws, worm and spur gear adjustable for top and bottom rolls. Mill spindles are of the wabbler type connected to a three-high pinion stand equipped with 29-in. pitch diameter alloy forged steel pinions. Mill drive 10 to 1 reduction, flywheel equipped and connected by lead spindle to 2000-hp a-c motor (wound rotor type) 360 rpm. Average speed of mill is 275 fpm.

TABLE I

Operating Force—Plant A

(Assumed on the basis of rolling 200,000 net tons of steel per year—2 shifts, 5 days, 40 hours per man per week)

	First Shift	Second Shift	Third Shift	Total
Supervision and clerical				
General Superintendent	1	..	..	1
Superintendent (maintenance—mechanical)	1	..	..	1
Superintendent (maintenance—electrical)	1	..	..	1
Turn foreman	1	1	..	2
Senior and junior clerk	2	1	..	3
Janitor	1	..	..	1
Mill operators and helpers				
Mill operator and assistant	2	2	..	4
General mill turn foreman	1	1	..	2
Heater and helpers	4	4	4	12
Ingot recorder	1	1	..	2
Cranemen—Soaking pit	1	1	1	3
Blooming mill	1	1	..	2
Bloom and billet storage	1	1	..	2
Shear operator	1	1	..	2
Bloom and billet marker	1	1	..	2
Cooling bed operator	1	1	1	3
Mill motor room operator	1	1	..	2
Mill recorder	1	1	..	2
Greaser	1	1	..	2
Maintenance				
Millwrights, motor inspectors, etc.	5	5	..	10
Turn laborers	5	5	..	10
Pipe fitter	1	1	1	3
Roll turner	1	..	..	1
Total (Producing and maintenance labor)				73

Item 7: Mill delivery and shear approach table—Length approximately 42 ft.

Item 8: Downcut type bloom shear—With capacity to cut 100 sq in. Shear, crank, pitman and clutch motor-operated type, driven by 75-hp, a-c wound-rotor, type motor.

Item 9: Crop pusher—Motor-operated.

Item 10: Shear gauge—Screw type, motor-operated, arranged for gaging maximum length of 20 ft.

Item 11: Shear depressing table—Motor-operated, lineshaft driven rollers.

Item 12: Crop chutes and buckets

Item 13: Shear gage delivery table including bloom scale

Item 14: Cooling bed runin table

Item 15: Bloom and billet pushers

Item 16: Motor-operated bloom and billet cooling beds and cradles

Item 17: Complete oil and grease lubrication systems, hydraulic and descaling systems and compressed-air controls

Item 18: Roll lathe, size 36 in. x 15 ft

For further processing, blooms and billets are transferred to adjacent mill buildings for reheating and subsequent rolling to finished products on billet or structural mills.

Typical products to be rolled—

Ingot size	*Weight, lb*	*29-In. 3-high mill, finished size, in.*	*Approximate production, tons per hr*
12½ x 12½ } Length of ingot	2400	5 x 5	50 based on 8 x 8-in. bloom
15 x 15 } varies be-	3200	5 x 5 to 7 x 7	
18½ x 18½ } tween 7 and 8 ft	5350	6 x 6 to 10 x 10	

Average yield, per cent

88 when rolling rimmed and semi-killed steel (open top ingot)
79 when rolling hot top ingots (alloy, electric furnace and quality carbon steels)

Operating data—The plant with the 29 x 96-in. three-high mill installation with its main mill drive, auxiliary motors, soaking pits, cranes, etc., has total power consumption of average 24 kwhr per ton of product based on output of 50 tons per hour.

Water consumption—Total per ton of products including descaling, roll cooling, etc., approximately 750 gal.

Lubricants—Consumption of lubricating grease applied to machinery through various pressure and hand-operated grease systems, 0.20 lb per ton of product. Consumption of lubricating oil applied to machinery through various circulating systems, 0.06 gal per ton of product.

Rolls—Although the three rolls in the stand are of the same length, namely, 96 in., the diameters are slightly different. Average diameter, in.: Top roll—29¼ center roll—29, and bottom roll—28¾. New rolls are installed with 30$^{11}/_{16}$ in. diam and are dressed down during subsequent rolling to a minimum of 28 in. diam at which time they are scrapped. Average life of cast alloy steel rolls when rolling mild steel—300,000 net tons of products; when rolling alloy steels—200,000 net tons. Computed into roll cost, including roll dressing, this amounts to an average of $0.07 per ton of rolled mild steel.

Operating cost—Considering a mill output figure of 200,000 net tons of semi-finished products per year operating two shifts, five days per week, the direct conversion cost from ingots to blooms or billets on described mill installation, Plant A, is $7 to $8 per ton of mild carbon, rimmed or semi-killed steel.

In addition to direct conversion costs, we have to consider following indirect additional charges.

Let us assume direct conversion cost	$ 7.35 per ton
Carrying charges of plant "A" consisting of depreciation, interest on investment, insurance, real estate taxes, plant administrative expenses and other fixed charges = 15 per cent	
$\frac{9,327,500 \times 0.15}{200,000}$ =	7.00 per ton
Total cost	$14.35 per ton

TABLE II

Capital Cost Estimate—Plant A

(All prices based on costs during June, 1956)

			Materials and Equipment	Erection and Installation	Total
A.	Buildings				
	Soaking pits	50 x 150 ft			
	Soaking pit leanto	25 x 120 ft			
	Blooming mill	75 x 260 ft			
	Bloom and billet storage	75 x 100 ft			
	Motor room	50 x 90 ft			
	Roll shop and repair shop (erected including structural steel, roofing, siding and foundation)	50 x 90 ft			$ 600,000.00
B.	Building utilities				
	Water, sewer, lighting, compressed air, etc.				125,000.00
C.	Cranes (erected)				
	Soaking pit	1—10/5 Ton			
	Blooming mill	1—35/10 Ton			
	Bloom and billet storage	1—10 Ton			
	Motor room	1—10 Ton	$ 700,000.00	$ 90,000.00	$ 790,000.00
D.	Soaking pits				
	6 Soaking pit furnaces as listed under Item 1 incl. covers, refractories, recuperators, stack, piping, instruments, motors and controls (including foundations)				$1,110,000.00
E.	Mill equipment				
	All mechanical mill and auxiliary equipment as listed under Item 2 to 18 inclusive (and interconnecting piping)		$2,000,000.00	$400,000.00	$2,400.000,00
F.	Electrical Equipment				
	Main drive motors and auxiliary motors, controls, switchgear, cable, conduit for soaking pits and mill equipment		$ 700,000.00	$500,000.00	$1,200,000.00
G.	Foundations				
	For mill and electrical equipment, buildings, etc.				$1,250,000.00
H.	Blooming mill office and sanitary facilities				$ 200,000.00
	Sub-total				$7,675,000.00
J.	Spares				
	10 Per cent of $4,400,000.00				$ 440,000.00
	Sub-total				$8,115,000.00
K.	Contingencies				
	10 Per cent of $7,675,000.00				$ 767,500.00
	Sub-total				$8,882,500.00
L.	Engineering and supervision of construction				
	5 Per cent of $8,890,000.00				$ 445,000.00
	Total *				$9,327,500.00

* This total sum does not include administrative, legal, purchasing, expediting and general supervisory expenses.

Production on the described three-high blooming mill is greatly affected by various improvements worked out during rolling practice, labor skill and carefully scheduling production.

The calculated man hours per ton of output, based on average production, would be 0.72.

Expansion of production—By adding additional soaking pits, thereby increasing the ingot heating capacity, the mill without changes to mechanical equipment is capable of rolling 300,000 tons per year, operating five days weekly but three shifts daily, fifty weeks per year or 6000 hr.

Still greater production may be achieved by increasing the yearly working hours, to say 7000. From there on, any increase in capacity demands a radical change of mill equipment.

Besides additional soaking pit capacity for larger size ingots, it will be necessary to replace the three-high mill with a modern two-high reversing mill installation as described under Plant B.

PLANT B

TWO-HIGH REVERSING BLOOMING MILL FOR MEDIUM PRODUCTION

The primary rolling mill equipment consists of a modern 36 x 78-in. two-high reversing mill stand, (Figure 3) direct-driven by a single 4000-hp reversing motor, 50/120 rpm.

This mill, complete with auxiliary equipment, is capable of rolling between 300,000 and 500,000 net tons of ingots per year to semi-finished products of blooms, billets as well as small slabs.

For the hypothetical case, we are reviewing an installation with annual production of 500,000 net tons.

Briefly, this plant consists of the following equipment.

Item 1: Six banks of soaking pit furnaces—(Two holes per bank, each hole 13 ft wide x 17 ft long x 9 ft deep.) See Figure 4. To heat 500,000 net tons of ingots per year uniformly throughout the individual ingots and several ingots in the pits at the same time. Pits to heat rapidly and economically mild steel ingots to 2400 F at closely controlled temperature for best quality and maximum rate of production in rolling. Fuel consumption: Average 1,305,000 Btu per ton when operating with natural gas (Cost of heating $0.70 to $0.76 per ton).

Item 2: Ingot transfer buggy—This receives hot ingots from soaking pit crane and delivers same to the approach table of the mill.

Item 3: Ingot receiving and mill approach table—Roller bearing equipped and lineshaft driven.

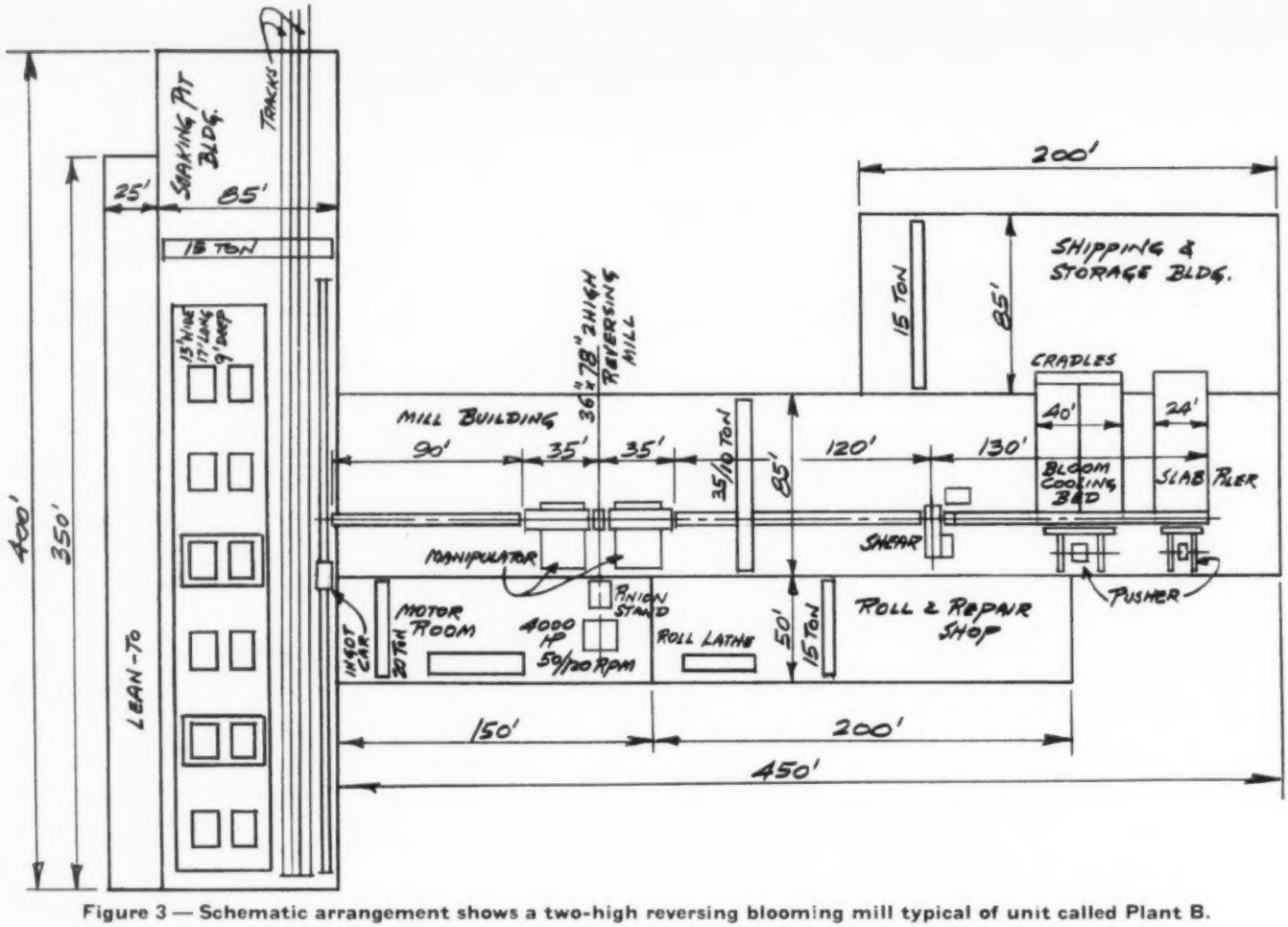


Figure 3 — Schematic arrangement shows a two-high reversing blooming mill typical of unit called Plant B.

Item 4: Front and back mill tables—Roller bearing equipped throughout, each lineshaft driven by two 75-hp motors. Feed rollers adjacent to mill stand.

Item 5: Double manipulator—Located in front and back of mill stand, rack and pinion operated. Lifting fingers for turning blooms and slabs are provided in the front section only.

Item 6: 36 x 78-in. Mill stand of conventional 2-high reversing type—Equipped with rolls 36-in. diam over the collars and bullhead pass, roll body 78 in. long. The rolls are mounted on phenolic-resin type bearings, water-lubricated. Screws are worm and spur gear driven by two 75-hp mill type motors. Mill spindles are of the universal type. Pinion stand, equipped with 36-in. pitch diam alloy forged steel pinions, is direct-connected through lead spindle to the 4000 hp shunt-wound, d-c motor. This motor is driven by a 2-unit motor-generator set consisting of two 1750-kw generators and one 3500-hp wound-rotor, induction motor taking 4800 volt. Speed of mill: 50/120-rpm (471/1130 fpm depending on roll diameter). Speed of screwdown: $7\frac{1}{2}$ to 15 fpm.

Item 7: Mill delivery and shear approach table

Item 8: Bloom and slab shear—Of the downcut type with a capacity to cut 8 x 8-in. blooms or 6-in. thick by 22-in. wide slabs or 4 x 38-in. wide slabs. Shear is driven by one 150-hp mill type motor.

Item 9: Shear crop pusher

Item 10: Shear gage—Screw type, motor-operated, arranged for gaging lengths from 6 to 20 ft.

Item 11: Shear depressing table—Motor-operated, lineshaft driven rollers.

Item 12: Crop chutes and buckets

Item 13: Shear gage and delivery table including slab scale

Item 14: Cooling bed runin table

Item 15: Bloom and billet pusher

Item 16: Bloom and billet cooling bed and piling cradles

Item 17: Slab piler runin table

Item 18: Slab pusher

Item 19: Slab piler

Item 20: Complete oil and grease lubrication systems,

Figure 4 — Plant B is serviced by six banks of two-hole pits.

TABLE III

Operating Force—Plant B

(Assumed on the basis of rolling 500,000 net tons of ingots per year in three shifts, six days, forty-eight hours per man per week, 7000 hours per year)

	First Shift	Second Shift	Third Shift	Total
Supervision and clerical				
Superintendent	1	..	..	1
Clerk (recorder)	1	1	1	3
Janitor	1	..	..	1
Mill operators and helpers				
Mill operator and assistant	2	2	2	6
Turn foreman	..	1	1	2
Gager	1	1	1	3
Heater	1	1	1	3
Ingot recorder and assistant	2	2	2	6
Cinder man	1	1	1	3
Cranemen—Soaking pit	2	2	2	6
Blooming mill	1	1	1	3
Bloom and slab storage	1	1	1	3
Shear operator and helper	2	2	2	6
Billet and slab marker	2	2	2	6
Bloom and slab piler and loader	2	2	2	6
Millwright and motor inspector	4	4	4	12
Greaser	1	..	..	1
Roll turner	1	..	..	1
Total (Producing and maintenance labor)				72

TABLE IV

Capital Cost Estimate—Plant B

(All prices based on cost during June, 1956)

		Materials and Equipment	Erection and installation	Total
A. Buildings				
Soaking pits	85 x 400 ft			
Soaking pit leanto	25 x 350 ft			
Blooming mill	85 x 450 ft			
Billet and slab storage	85 x 200 ft			
Motor room	50 x 150 ft			
Roll shop and repair shop (erected including structural steel, roofing, siding and foundation)	50 x 200 ft			$ 1,500,000.00
B. Building utilities				
Water, sewer, lighting, compressed air, etc.				200,000.00
C. Cranes (erected)				
Soaking pit	1—15-ton			
Hot mill	1—35/10 ton			
Billet and slab storage	1—15-ton			
Motor room	1—20-ton			
Roll and repair shop	1—15-ton	$1,000,000.00	$110,000.00	$ 1,110,000.00
D. Soaking pits				
12 Soaking pit furnaces as listed under Item 1 including covers, two cover cranes, refractories, recuperators, stack, piping, instruments, motors and controls, (including foundations)		$3,480,000.00	$275,000.00	$ 3,755,000.00
E. Mill equipment				
All mechanical mill and auxiliary equipment as listed under Item 2 to 21 inclusive and interconnecting piping		$3,400,000.00	$550,000.00	$ 3,950,000.00
F. Electrical equipment				
Main drive motors and auxiliary motors, controls, switchgear, motor-generator sets, cable, conduit for soaking pits and mill equipment		$1,000,000.00	$800,000.00	$ 1,800,000.00
G. Foundations				
For mill and electrical equipment, buildings, etc.				$ 1,500,000.00
H. Blooming mill office and sanitary facilities				$ 250,000.00
Sub-total				$14,065,000.0
J. Spares				
10 Per cent of $9,000,000.00				900,000.00
Sub-total				$14,965,000.00
K. Contingencies				
10 Per cent of $14,065,000.00				$ 1,406,500.00
Sub-total				$16,371,500.00
L. Engineering and Supervision of construction				
5 Per cent of $16,300,000.00				815,000.00
Total*				$17,186,500.00

* This total sum does not include administrative, legal, purchasing, expediting and general supervisory expenses.

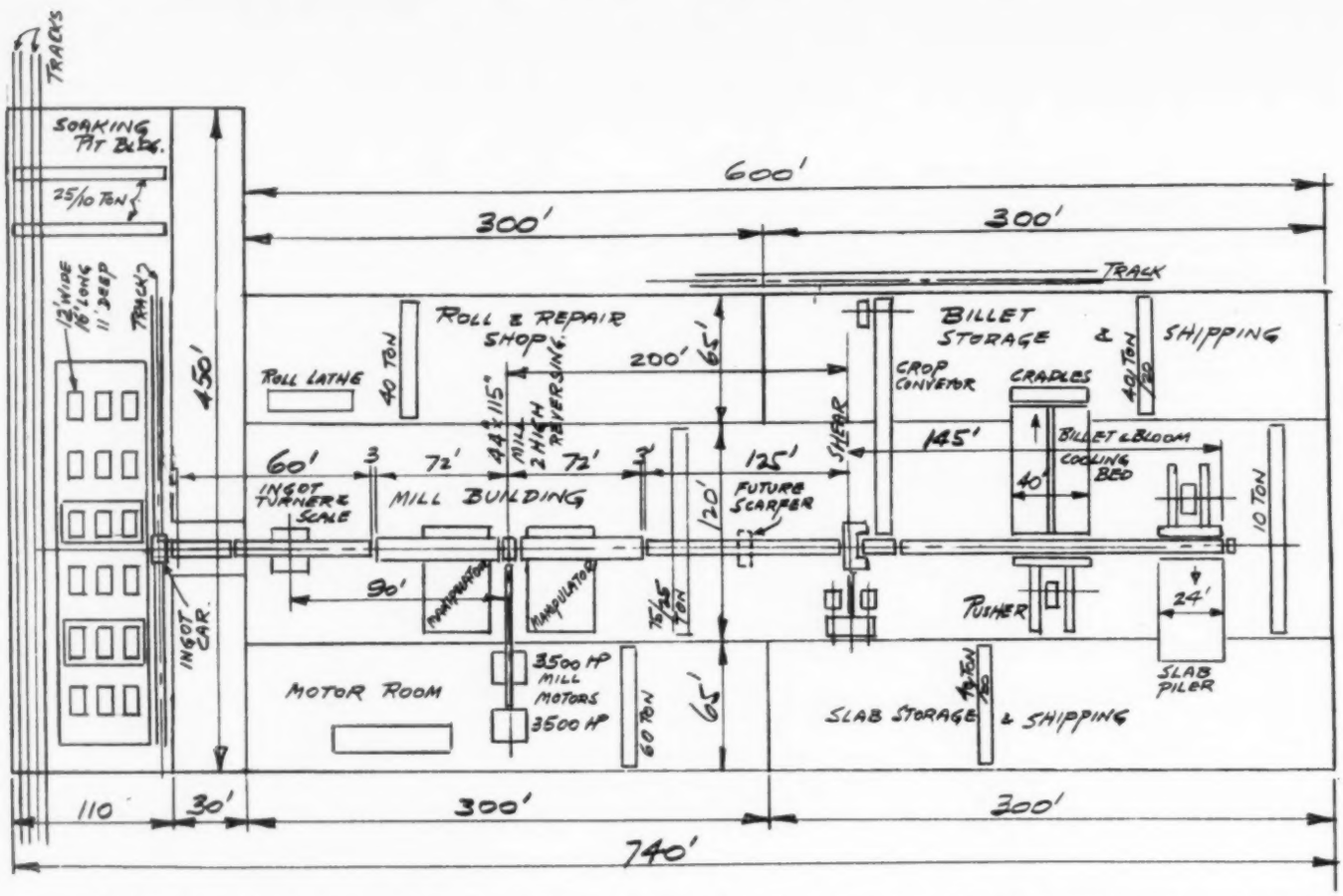


Figure 5 — The two-high reversing blooming mill layout shown is typical of modern high production equipment in unit called Plant C.

hydraulic and descaling systems and compressed air controls.

Item 21: Roll lathe, 3¼ in. x 24 ft

For further processing, blooms and billets may be further reduced on a continuous billet mill in line with the blooming mill or transferred to adjacent mill buildings for reheating and further rolling on billet or structural mill.

Slabs are transferred to cooling and conditioning sites for subsequent rolling on hot strip mills.

Typical products to be rolled (low carbon steel)—

	Ingot size, in.	*Weight, lb*	*36-In. blooming mill, finished size, in.*	*Approximate production, tons per hr*
For blooms and billets	21¼ x 21¼	6214	3 x 3 and 4 x 4	40
	24½ x 24½	7380 to 12,800	5 x 5 and 5½ x 5½ 6 x 6 and 8 x 8	60 50/60
For slabs	23 x 39	15,000	3 x 22 and 6 x 22	70
	23 x 44	18,500	4 x 38¼	80
	26¾ x 44	21,500	5 x 38¼	90

Average yield, per cent
88 to 89 when rolling low carbon steel.
83 when rolling high carbon steel.
75 when rolling stainless steel.

Operating data—Plant B with the 36 x 78-in. two-high mill installation, operating on the assumption of producing 500,000 net tons of semi-finished products per year, will consume an average of 50 kwhr per ton of production.

Water consumption—Total per ton of product including descaling, roll cooling, etc., approximately 300 gal.

Lubricants—Consumption of lubricating grease applied to machinery through various pressure systems, $0.01 per ton of product. Consumption of lubricating oils applied to machinery through various circulating systems, $0.02 per ton of product.

Rolls—Average life of one set of cast alloy steel rolls when rolling mixed products, 300,000 tons. Computed into roll cost, this amounts to an average of $0.10 per ton of rolled steel. Roll turning and dressing, $0.11 per ton. Total: $0.21 per ton of rolled steel.

Figure 6 — This 45 x 115-in. two-high reversing mill is typical of Plant C.

Operating cost—Considering a mill output figure of 500,000 net tons of semifinished products per year, operating in three shifts, six days per week, 7000 hours per year, the conversion cost from ingots to blooms, billets or slabs on above described mill installation, Plant B, is $5 to $6 per ton when rolling low carbon rimmed or semi-killed steel, or $6.50 to $8.50 when rolling stainless steel of the 18-8 variety.

To analyze above listed conversion costs, let us assume the rolling of average product mix consisting of rimmed steel, medium and high carbon as well as some stainless steels, based on a yearly production of 500,000 net tons, operating at an average yield of 81 per cent.

Direct conversion costs from ingot to blooms or slabs are divided as follows:

Supervision and clerical	$ 0.22 per ton
Direct operating labor	0.98
Soaking pit fuel	0.76
Oil, grease, hand tools, etc.	0.20
Scarfing tools	0.03
Rolls without dressing	0.10
Utilities (power, water, oxygen)	0.99
General expenses	0.06
Maintenance (labor and material)	0.40
Major repairs	0.97
Soaking pit rebuilding	0.46
Roll shop (roll dressing)	0.11
Total cost	$ 5.28

In addition to the direct conversion cost, we must consider the following additional charges.

Carrying charges of plant "B" consisting of depreciation, interest on investment, real estate taxes, insurance, plant administration, expenses and other fixed charges = 15 per cent

$$\frac{17{,}186{,}500 \times 0.15}{500{,}000} = \$5.16 \text{ per ton}$$

Total cost $10.44 per ton

All modern blooming mill facilities are showing a downward trend of manhour requirements for the production per ton of steel. This efficiency of the mill is affected principally by the performance of the mill itself, but depends also to a certain extent on various improvements worked out in rolling practice, labor skill and careful scheduling of production.

On above selected mill, described under Plant B, production is rated at 0.34 manhours per ton when rolling mixed products, low carbon as well as alloy steels at 81 per cent average yield.

Expansion of production by adding to existing facilities—The blooming mill as described under Plant B, when rolling a favorable product mix, is calculated for a maximum yearly production of 500,000 net tons, operating six days weekly, three shifts daily, fifty weeks per year or 7000 hours per year.

Should ever-expanding markets demand more capacity, over 500,000 tons, a second but larger blooming mill, say 44 in. located in front of the existing mill, may be projected.

By careful planning, this addition may be added without an appreciable shutdown of existing mill facilities during the changeover.

This new 44-in. mill will be able to roll larger ingots, to 12 x 12-in. or 14 x 14-in. blooms which subsequently will be reduced in the 36-in. mill to smaller blooms and billets.

Such a two-mill combination will produce in excess of 1,000,000 tons per year.

PLANT C
THE TWO-HIGH REVERSING BLOOMING AND SLABBING MILL FOR HIGH PRODUCTION

The primary rolling mill equipment consists of a modern 44 x 115-in., 2-high reversing mill stand, driven-direct by two 3500-hp reversing motors, 40/80 rpm. See Figures 5, 6 and 7.

This mill complete with auxiliary equipment is capable of rolling between 500,000 and 1,000,000 net tons of ingots per year to miscellaneous semi-finished products of blooms and slabs, up to 60-in. wide.

This type of mill incorporates the most up-to-date improvements and is extensively used throughout the steel industry where maximum production is of prime importance.

For the hypothetical case, we are figuring an installation with an annual production of 900,000 net tons, considering a future expansion to, say 1,200,000 net tons.

Briefly, this plant consists of the following equipment:

Item 1: Six banks of soaking pit furnaces—(Three holes per bank, each hole 12 ft wide x 16 ft long x 11 ft deep). See Figure 8. To heat 900,000 net tons of ingots per year uniformly throughout the individual ingots and several ingots in the pits at the same time. Pits to heat rapidly and economically, mild steel ingots to 2300 F at closely controlled temperature for best quality and maximum rate of production in rolling. Fuel

Figure 7 — Mills such as this produce up to 1,200,000 net tons per year.

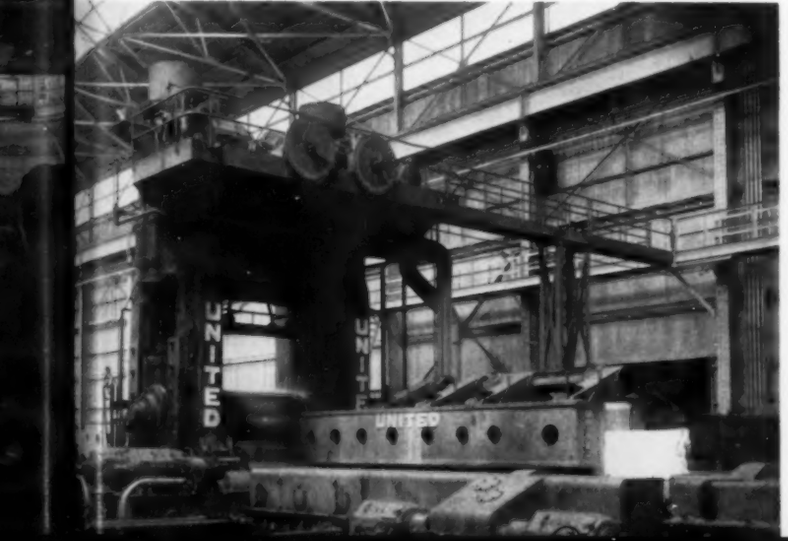


Figure 8 — Adequate heating capacity is essential for high production mill operation.

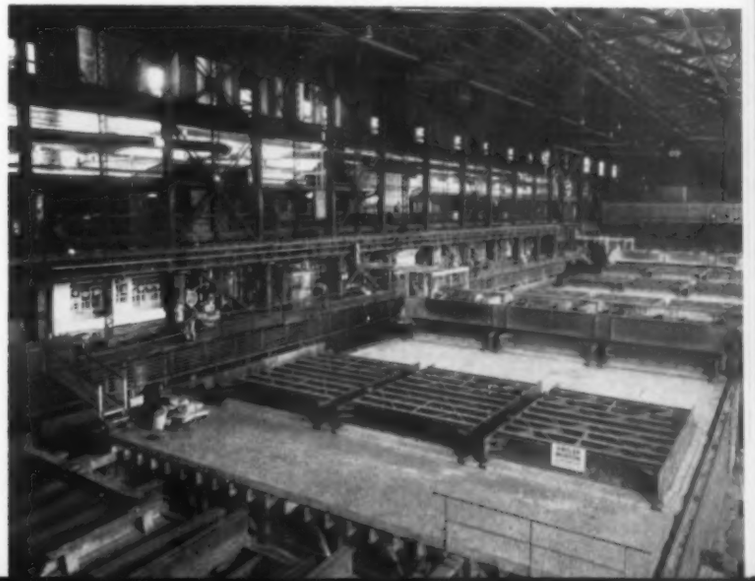


TABLE V

Operating Force—Plant C

(Assumed on the basis of rolling 900,000 net tons of ingots per year in three shifts (8-hour), five days per week, fifty weeks per year)

	First Shift	Second Shift	Third Shift	Total
Supervision and clerical				
Superintendent and assistant	1	..	..	1
Mechanical foreman	1	..	..	1
Electrical foreman	1	..	..	1
Senior and junior clerk	2	1	..	3
Janitor	1	..	..	1
Mill operators and helpers				
Mill operator and assistant	2	2	2	6
General mill turn foreman	1	1	1	3
Heater and helpers	3	3	3	9
Ingot recorder	1	1	1	3
Cinder men	2	2	2	6
Cranemen—Soaking pit	2	2	2	6
Blooming mill	1	1	1	3
Bloom and slab storage	2	2	2	6
Shear operator	1	1	1	3
Billet and slab marker	1	1	1	3
Mill motor room operator and assistant	2	2	2	6
Cooling bed operator	1	1	1	3
Bloom and slab piler	1	1	1	3
Millwright and motor inspector	2	2	2	6
Greaser	1	1	1	3
Turn laborer	1	1	1	3
Maintenance				
Electrician and helper	2	2	2	6
Welder	1	1	1	3
Pipe fitter and helper	2	2	2	6
Machinist and helper	2	..	..	2
Roll turner and helper	2	..	..	2
Total (Producing and maintenance labor)				98

consumption: Average 875,000 Btu per ton of steel.

Item 2: Ingot transfer buggy—This receives hot ingots from soaking pit crane and delivers same to approach table of the mill.

Item 3: Ingot receiving table including ingot turning device and scale—Table roller bearing equipped and lineshaft driven.

Item 4: Mill approach table

Item 5: Front and back mill tables—Roller bearing equipped throughout, each lineshaft driven by two 150-hp motors. Feed rollers adjacent to mill stand separately driven.

Item 6: Double manipulator—Located in front and back of mill stand, rack and pinion operated. Lifting fingers for turning blooms and slabs are provided in front section at entry side of mill only.

Item 7: 44 x 115-in. mill stand—Of conventional two-high reversing type, equipped with alloy steel rolls, 45 in. diam x 115 in. body length, equipped with roller bearings mounted in cast steel chocks. Forged steel screws are worm and spur gear driven (4 to 1) by two 50-hp mill type motors. Top and bottom rolls are individually motor-driven by two 3500 hp motors through universal mill type spindles and couplings. The two main motors are driven by a three unit motor-generator set, flywheel equipped, consisting of two 3000-kw generators and one 5000-hp wound-rotor induction motor. Speed of mill: 40/80 rpm (460/920 fpm depending on roll diameter) Speed of screwdown: 19.16 fpm.

Item 8: Mill runout table

Item 9: Shear approach table

Item 10: Bloom and slab shear, down and upcut type—With capacity to cut 15 x 15-in. blooms or 6 in. thick x 60 in. wide slabs. Knife pressure: 2,000,000 lb. Shear driven by two 500-hp mill type motors, shear operating at the rate of nine cuts per minute.

Item 11: Crop pusher—Motor-operated.

Item 12: Shear gage—Screw type, motor-operated, arranged for gaging lengths from 6 to 20 ft.

Item 13: Shear pull back table—Motor-operated, lineshaft driven rollers.

Item 14: Chop chute

Item 15: Chop conveyor and discharge chute

Item 16: Shear runout table including scale

Item 17: Cooling bed runin table

Item 18: Bloom and billet pusher

Item 19: Bloom and billet cooling bed and piling cradles

Item 20: Slab piler runin table

Item 21: Slab pusher

Item 22: Slab piler

Item 23: Complete oil and grease lubrication systems, hydraulic and descaling systems and compressed air controls

Item 24: Roll lathe, size 44 in. x 34 ft

For further processing, blooms may be reduced to billets on a secondary blooming mill similar to the one listed under Plant B, or subsequently rolled on a continuous billet mill. Blooms may also be transferred to adjacent mill buildings for reheating and further rolling on billet or structural mill.

Slabs are usually transferred to cooling and conditioning sites for subsequent rolling on hot strip mills.

Typical products to be rolled (See Figure 9)—

	Ingot size, in.	*Weight, lb*	*44-In. blooming mill, finished size, in.*	*Approximate production, tons per hr*
For blooms and billets	22 x 24 x 68	8600	8 x 8	150
	24 x 26 x 78	11,800	12 x 12	200
	24 x 26 x 78	11,800	14 x 14	225
For slabs	26 x 47 x 85	25,000	4½ to 8	250
	26 x 66 x 72	30,000	60 wide maximum	300

Average yield, per cent

Blooms and slabs: 86 when rolling rimmed or semi-killed steel
80 when rolling hot top (killed steel) ingots

TABLE VI
Capital Cost Estimate—Plant C
(All prices based on cost during June, 1956)

		Materials and Equipment	Erection and Installation	Total
A. Buildings				
Soaking pits	110 x 450 ft			
Soaking pit leanto	30 x 450 ft			
Blooming mill	120 x 600 ft			
Billet storage	65 x 300 ft			
Slab storage	65 x 300 ft			
Motor room	65 x 300 ft			
Roll shop and repair shop (erected including structural steel, roofing, siding and foundation)	65 x 300 ft			$ 2,700,000.00
B. Building utilities				
Water, sewer, lighting, compressed air, etc.				250,000.00
C. Cranes (erected)				
Soaking pit	2—25/10-ton			
Hot mill	1—75/25-ton			
	1—10-ton			
Billet storage	1—40/20-ton			
Slab storage	1—40/20-ton			
Motor room	1—60-ton			
Roll and repair shop	1—40-ton	$2,200,000.00	$250,000.00	$2,450,000.00
D. Soaking pits				
6 Banks of soaking pit furnaces as listed under Item 1 including covers, cover cranes, refractories, recuperators, stack, piping, instruments, motors and controls (including foundations)				5,000,000.00
E. Mill Equipment				
All mechanical mill and auxiliary equipment as listed under Item 2 to 24 inclusive (including interconnecting piping)		$4,300,000.00	$600,000.00	$ 4,900,000.00
F. Electrical Equipment				
Main drive motors and auxiliary motors, controls, switchgear, motor-generator sets, cable and conduit for soaking pits and mill equipment		$2,000,000.00	$1,000,000.00	$ 3,000,000.00
G. Foundations				
For mill and electrical equipment, buildings, etc.				$ 1,700,000.00
H. Blooming mill office and sanitary facilities				250,000.00
Sub-total				$20,250,000.00
J. Spares				
10 Per cent of $12,750,000.00				1,275,000.00
Sub-total				$21,525,000.00
K. Contingencies				
10 Per cent of $20,250,000.00				2,025,000.00
Sub-total				$23,550,000.00
L. Engineering and Supervision of Construction				
5 Per cent of $23,500,000.00				1,177,500.00
Total*				$24,727,500.00

* This total sum does not include administrative, legal, purchasing, expediting and general supervisory expenses.

Operating data—Equipment as listed under Plant C, operating on the assumption of producing 900,000 net tons of semi-finished products per year, will consume 16 kwhr per ton of production. This includes only main mill drive and auxiliaries.

Water consumption— Total per ton of steel including descaling, roll cooling, etc., approximately 1000 gal.

Lubricants—Consumption of lubricating grease and oil applied to machinery through various pressure and circulating systems, $0.03 per ton of products.

Rolls—Average life per pair of cast alloy steel rolls, 450,000 tons of products (low carbon steel). Computed into roll cost, this amounts to an average of $0.07 per ton of rolled steel. Roll turning and dressing $0.06 per ton. Total $0.13 per ton.

Operating cost—Considering mill output figure of 900,000 net tons of semi-finished products per year, operating three 8-hour shifts per day, five days per week, fifty weeks per year, the direct conversion cost from ingot to blooms, billets or slabs on mill installation Plant C is $4 to $5 per ton of rimmed or semi-killed steel.

Scrap losses are not included in above conversion cost. When rolling rimmed steel, scrap losses average $1.70 per ton. When rolling hot top (killed steel) ingots, scrap losses average $2.40 per ton. Slab or billet conditioning is figured at an average of $1.00 per ton.

Direct conversion costs from ingots to blooms or slabs are arrived at approximately as follows:

Direct labor	$0.59 per ton
Repairs and maintenance	0.21
Supplies	0.03
Services (power, steam, air)	0.50
Roll expenses (including dressing)	0.13
General works expenses (plant manager and staff)	0.14
Oil, grease, hand tools, etc.	0.10
Supervision and general expenses which include machine and electric shops, soaking pit fuel and maintenance, general repairs and maintenance of electrical and mechanical equipment	1.28
Miscellaneous major repairs (such as soaking pit rebuilding, etc.)	1.80
Total direct conversion cost	$4.78
In addition to the direct conversion cost, we must add the following additional charges.	
Carrying charges of plant "C"—consisting of depreciation, interest on investment, real estate taxes, insurance, plant administration expenses and other fixed charges = 15 per cent	
$\frac{24,727,500 \times 0.15}{900,000}$ =	4.12
Total cost	$8.90 per ton

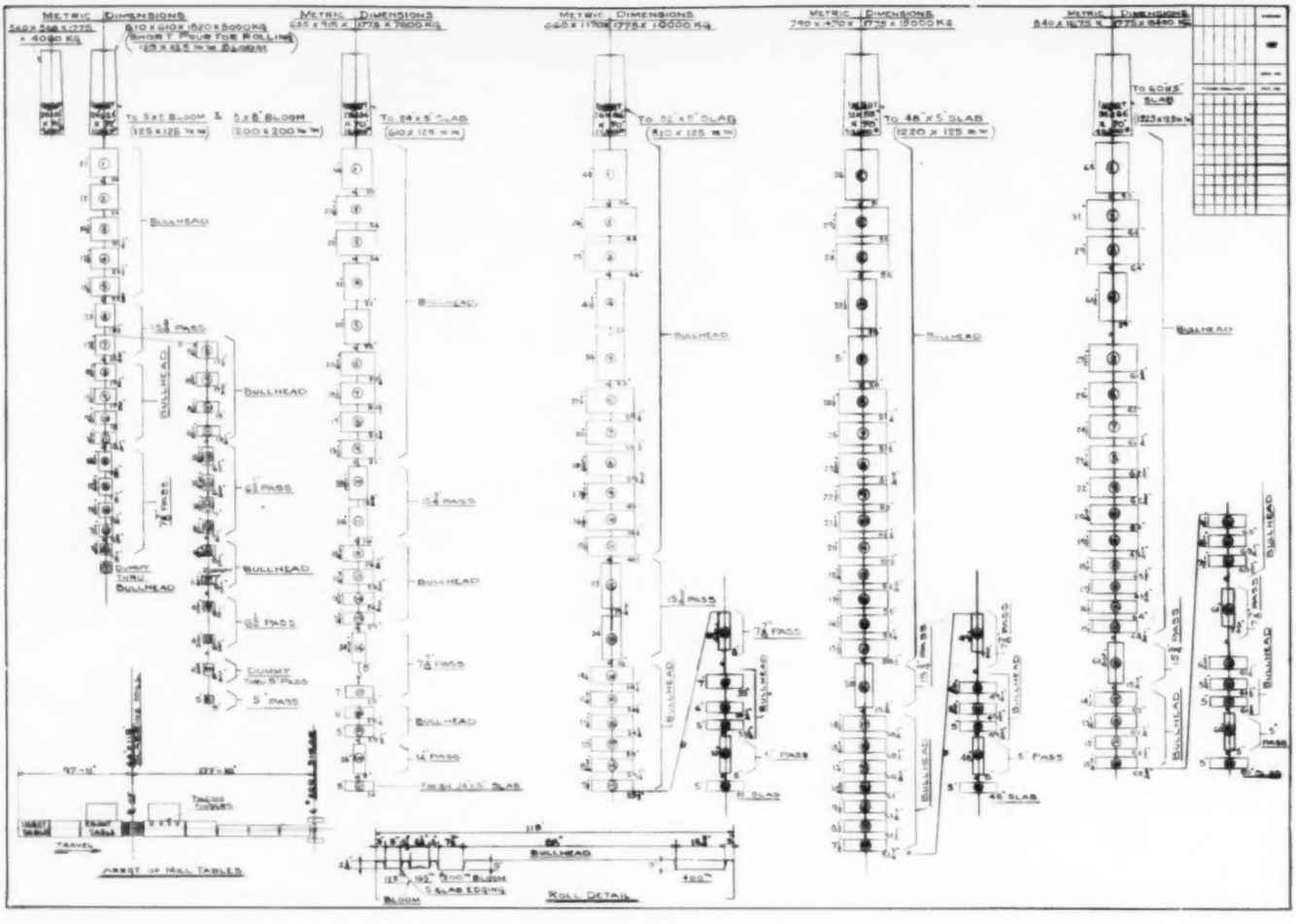


Figure 9—Pass schedule for 45 × 115-in. mill.

As stated previously, all modern blooming and slabbing mill facilities are showing a downward trend of manhour requirements for the production per ton of steel. Not only is the mill efficiency affected by the smooth performance of the mill itself, but depends also on various improvements established in the rolling practice, labor skill and careful production scheduling.

This mill, as described under Plant C, is productively rated at:

0.10 Man hours per ton on soaking pits
0.09 Man hours per ton on blooming mill
0.19 Total manhours per ton of steel

Expansion of production by adding to existing mill facilities—The blooming and slabbing mill as described under Plant C is calculated for a production of 900,000 net tons per year, operating three 8-hour shifts per day, five days per week, fifty weeks per year, or 6000 hours per year.

By adding additional soaking pits, thereby increasing the ingot heating capacity, the mill, without changes to mechanical equipment, is capable of rolling more than 1,000,000 net tons per year, operating up to 7000 or 8000 hours per year, in fact up to 1,500,000 tons when rolling a favorable product mix.

Should ever expanding markets demand still higher production, a smaller secondary blooming mill, similar to the one listed under Plant B, may be projected. This additional 32-in. mill may be installed without appreciable shutdown of existing mill facilities and will roll 12 x 12 in. or 14 x 14 in. blooms down to smaller size billets; such a two-mill combination will produce far in excess of 1,000,000 net tons per year.

SUMMARY

In conclusion the above studies indicate that the investment as well as operating costs per ton of annual production declines with the increased size of plant.

A small plant with an annual ingot capacity from 50,000 to 200,000 net tons, estimated at $9,327,500 or approximately $46 investment per ton of output, will operate at total direct and indirect conversion cost of approximately $14.35 per ton.

A medium size plant with an annual ingot capacity from 300,000 up to 500,000 net tons, estimated at $17,186,500 or approximately $34, investment per ton of output, will operate at total direct and indirect conversion cost of approximately $10.44 per ton.

A large size plant with an annual ingot capacity from 500,000 to 900,000 net tons, estimated at $24,727,500 or approximately $27 investment per ton of production, will operate at total direct and indirect conversion cost of approximately $8.90 per ton.

PROBLEMS OF FINANCING NEW STEEL CAPACITY

By
W. B. BOYER
Treasurer
Republic Steel Corp.
Cleveland, Ohio

. . . . before the engineer can go ahead and build additional steel capacity, money for such construction must be obtained . . . . inadequate returns on steel investments caused by low prices and ever increasing costs are problems which must be overcome . . . .

▲ ANY major problem of the steel industry is likely to be a problem for everyone in the industry, whether engineers or financial men. Engineers in the great steel industry are dealing in conditions of difficulty which must be unsurpassed in any other industry. He must engineer equipment and processes to handle staggering loads under conditions of heat and stress which the uninitiated finds beyond belief. Yet most of them take these conditions as commonplace. The financial problems of the industry are also staggering. These result from the efforts of the industry, to provide the steel the country needs if it is humanly possible. Steel companies are now in the process of adding some 15,000,000 tons of new capacity to be completed in 1958, and it is taken pretty much for granted that expansion will continue at a fairly high rate for the foreseeable future. In 1956, alone, $1,500,000,000 will be spent for moderization and expansion.

The industry is determined to keep abreast of the country's need for new and better steels as technology grows more complex and exacting. Specifications that were good enough a few years ago often will not satisfy today's science and engineering. New alloys, better practice, improved controls are needed, and research is providing them. Instead of losing out to competing materials, steel is becoming more versatile every year.

Republic is doing its share, and is adding 1,776,000 tons of new capacity at a cost of $152,000,000. About half of these facilities are being added in Cleveland. The new facilities will round out production, particularly of types of steel now in short supply.

Republic is also stepping up its research effort. The new laboratory soon to be constructed in Independence will provide better facilities for certain types of pure research, as well as for product development.

Raw material supplies are also well in hand. Iron ore, which was a source of some concern a few years ago, can no longer be considered a problem. The completion of the taconite beneficiating plant in northern Minnesota, plus the development of major new sources in Labrador and Liberia, provide adequate reserves for many years ahead.

But even as Republic and the steel industry move forward with this spectacularly growing economy of ours, problems are multiplying that demand our most careful attention.

This talk could have been called "Growing Pains" because the phrase so aptly describes the industry's present conditions. It describes the entire economy, for that matter; but it is peculiarly applicable to the steel industry. The amazing thing about the title is that it can be applied so accurately to an industry that had its origins in our nation over 300 years ago.

The first two hundred years, of course, were primarily centuries of iron; but the invention of the bessemer converter in the middle nineteenth century ushered in the mass production of steel, and by the turn of the twentieth century steelmaking in the United States was on a heavy tonnage basis. Growing strongly through the '20s slowing for the depression years, and spurting ahead again with recovery and the onset of World War II, the industry entered the year 1946 with a capacity of 92,000,000 tons after retiring obsolete facilities at the end of the war.

Then came an explosion of growth having no precedent in history. The decades between 1900 and 1920

had seen a doubling and a re-doubling of steel capacity, with an average annual gain of a little over 2,000,000 tons. Compare this to the decade ending in 1955 which saw 36,000,000 added to our capacity, an average of well over 3,500,000 tons per year.

The steel industry is proud of that record, which has been so important in shouldering so heavy a share of the burden of building the America of today—the $400,000,000,000 economy that may reach half a trillion before another decade is done.

The industry has made that record in the face of tremendous problems. Problems which are rapidly approaching the point where something is going to have to be done about them.

First, look at capital costs.

Everybody knows that construction and equipment costs have skyrocketed since World War II. Companies have had to dig deep to pay the bill for new facilities. All industries have been hard hit, but steel has been hit particularly hard. Without going into a detailed analysis, consider this somewhat startling fact; to achieve a 40 per cent increase in capacity during the past decade, the steel industry had to raise its total capital investment a full 110 per cent!

Second, what had to be done to raise the money.

The steel industry took a beating during the depression. After the prosperity of the '20s, the sharp drop in steel prices and the disappearance of steel dividends during the early '30s stood out dramatically.

The result was a seriously depressed valuation of steel stocks on the market. This, in turn, created a situation unique in modern finance—a major industry that literally could not afford equity financing.

Improved earnings of recent years have gone far to restore confidence in steel stocks, but even today to buy Republic stock at $50 would be the equivalent of buying a ton of ingot capacity for $75; yet the present low-cost expansion program is costing us $85 per ton.

This difference is bad enough, but unless steel further improves the earnings base, the difference will increase because of the rising expansion costs of the future.

This low valuation on its stocks is the fundamental reason why the steel industry has been unable to use equity financing. Whereas in industry as a whole, during recent years, some 20 per cent of all corporate securities offered for sale have been stocks, there was only one issue of steel stock on the postwar era, and it was not a major operation.

Instead, it has been necessary to reinvest a disproportionate amount of net earnings, making up the remainder of the rising cost of modernization and expansion by large-scale borrowing.

This reinvestment policy has been hard on the stockholders, but there was no alternative. In seven of the ten years from 1946 through 1955, stockholders received less than half of net earnings as dividends. During these years, 54 to 62 per cent of net earnings was reinvested in the business.

In spite of this general high level of reinvestment, the industry's long-term debt began a rapid rise in 1945 that reversed itself in only one year, 1953. By the end of 1955, the long-term debt burden had risen 217 per cent above the 1945 level, or five and one-half times the percentage increase in capacity for that same period.

The figures would have looked still worse if it had not been possible to achieve large tonnage increases by rounding out existing facilities at comparatively low cost. Republic's present expansion program is an excellent example. By making the most of the rounding out process, there is a gain of 1,776,000 tons of capacity for $152,000,000 or about $85 per ton.

Republic is nearing the end of this rounding out process, and the rest of the industry is in the same fix. The day can be seen in the not-too-distant future when new tonnage can be gained only by building from the ground up, and at a cost one does not like to think about—but must.

Republic's next expansion program, in which the company will still be able to utilize some existing facilities, may cost as high as $200 per ton of annual capacity. The next may reach $300 to $350.

From simple arithmetic, this figures that if the cost per ton had been $350 this year, the 1,776,000 ton program would have cost not $152,000,000, but $622,000,000—almost as much as has been spent or appropriated for capital items since the end of the war.

At present prices and operating costs, as nearly as can be estimated, a completely integrated steel plant built at such expense would have difficulty earning more than one or two per cent on the investment.

It is not stretching a point to say that all of these problems can be traced back to one basic fact: the earnings base of the steel industry has not been high enough. The industry has been working hard to improve its position in preparation for tomorrow's high capital needs, but greater progress must be made.

There are signs, however, that conditions are beginning to improve. In 1955, for example, the steel industry's rate of return on the book value of its net assets equalled the average of all manufacturing for the first time in over three decades. It might have been possible to make further progress this year except for the adverse impact of the five-week steel strike.

This rise in steel earnings *must* continue until a base is established that will enable the industry to go out into the market and raise the equity capital needed to finance the expansion ahead. The word is "must," because adequate supplies of steel are a basic necessity in a growing economy. The industry must continue to expand, and it must do it in an orderly fashion, not in frantic bursts of activity in times of crisis. In the case of Republic, earnings will be watched to see that they are realistic in terms of long-range as well as short-range needs.

It is not known, at this moment, how the enormous cost of our future expansions will be met, but it will be done. The events of the past decade have opened all eyes, to the magnificent potential of this country and its people. What industry can do when its leaders combine faith and creativity with good business sense and sound economics, is evident.

This is a new world being built, a world in which the only limit to physical accomplishment seems to be the breadth and scope of imagination; in which change must be measured in decades, rather than centuries.

The problems will be great, but the rewards will be greater if all continue to work together in the spirit of friendly competition that has made "free enterprise" the watchword of the western world.

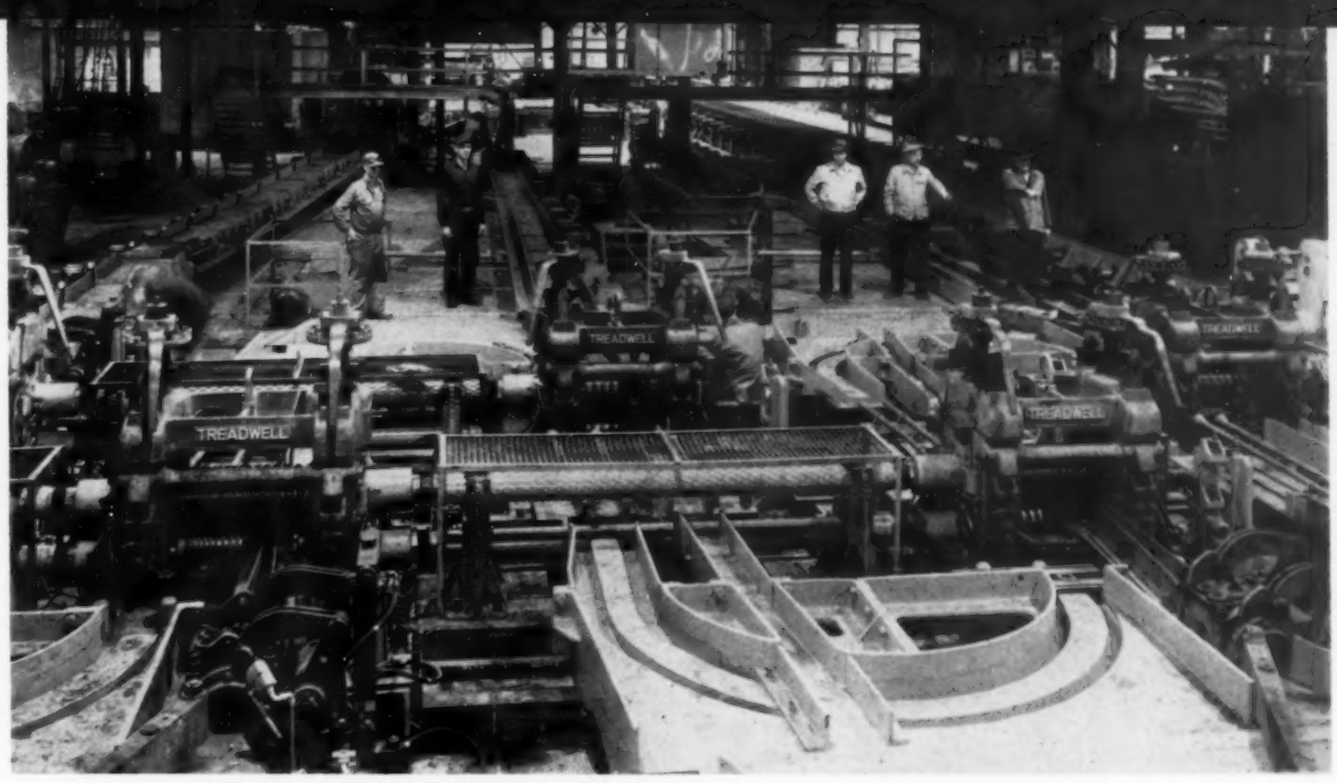


Figure 1 — Mill at Phoenix was designed to manufacture a wide range of products.

Flexible High Speed Bar Mill at Phoenix

By HUGH H. CAMPBELL

Manager of Manufacturing, Steel Div., Phoenix Manufacturing Co., Joliet, Ill.

▲ THIS paper describes the 12-in. modern bar mill of the Phoenix Manufacturing Co., at Joliet, Ill. For 73 years, this company has manufactured horseshoes and special sections at their plant at Joliet, Ill., rolling sections on hand bar mills. It was only logical then that they should branch out into the construction of a large modern bar mill, taking the maximum advantage of the existing buildings and facilities and with the view in mind of future expansion of rolling mill equipment.

The objectives in designing this mill were: (1) a wide range of finished products, (2) finish at relatively high speeds, and (3) flexibility in changing from section to section.

The plans also contemplated the rerolling of railroad axles as well as billets, and possibly the rolling of special sections. The mill was designed and built on the basis of the requirements mentioned above, starting operations on September 16, 1954, when the first bar was rolled experimentally on the mill. Basically the mill now consists of a continuous reheating furnace, a three-high, 20-in. roughing stand, a cross country mill with six, two-high, non-reversing 12-in. stands in staggered arrangement comprising: four 12-in. intermediate stands, one leader stand, one finishing stand, and a 250-ft single hot bed with shears.

Excavation and erection was started in December

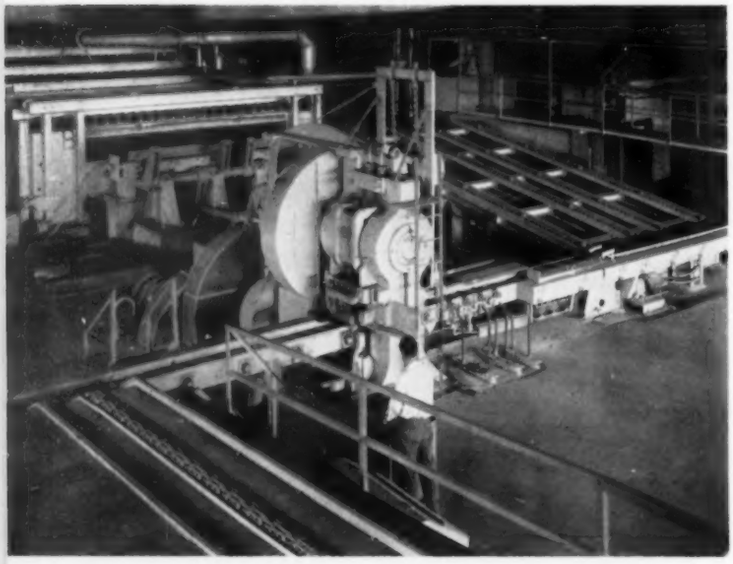
. . . . new mill at Phoenix features finishing on roughing mill, built-in repeaters and quick changes, use of sweep arms instead of skew tables, interchangeable rest bars, and new refinements in automatic operation of the hot bed . . . .

Figure 2 — Billet storage area is serviced by two 10-ton cranes.

1951, with most of the work contracted to local firms. Excepting for a completely modern warehouse, all of the existing buildings were revamped and modernized to suit the installation of the new rolling mill equipment, which has made for a compact mill arrangement at relatively low cost.

The 3-high roughing mill operates at a maximum speed of 105 rpm. It is driven through a 4.025 to 1 reduction gear and pinion unit by a 1500-hp, 600-volt d-c motor. The motor-generator set connected to this motor consists of a 2100-hp, 720-rpm, 4130-volt, 60-cycle synchronous motor coupled to two electrically parallelled, 600-volt, 750-kva, d-c generators. Two of the intermediate stands, numbers 1 and 3 are driven by one motor through another set of 12-in. pitch diameter pinions. Each of these motors is 700-hp, 600-volt, d-c, 150 to 525-rpm. The speeds of these motors are adjusted with field rheostats. The No. 5 leader stand and No. 6 finishing stand are each driven through 12-in. pitch diameter pinions by a 600-hp, 600-volt, d-c, 250 to 750-rpm motor with speeds controlled by field rheostats. All four of these motors are connected in parallel to a 2500-hp, 4160-volt, 60-cycle synchronous motor driving a 1750-kw generator.

Figure 3 — Billet sizes range from 2¼ x 2¼ to 4 x 4 in. although the design provides for a wider range of products.



The range of billet sizes used at the present time is from 2¼ x 2¼ to 4 x 4 in. inclusive, although the range provided for in the mill and furnace design was from 1¾ x 1¾ to 6 x 6-in. billets and railroad car axles. The billet storage area is serviced by two 10-ton overhead cranes with 73 ft-3 in. span, is a right angle to the mill and is an extension of furnace building. The billets are stored in racks, 86 in number with 43 on each side of a single track, which holds up to five railroad cars. This storage area is 214 ft in length and 73 ft wide. As the billets are moved from this storage area to be charged, they are placed on a sloping bed equipped with a conveyor chain which carries the billets down to a roller table in front of the billet shears, which cuts the billets to predetermined lengths. The sheared billets are moved by the back roller shear tables to an inclined bed equipped with a chain conveyor which conveys the billets to the furnace charging roller table. The railroad car axles are also stored in this area and are separated to size as they are unloaded and piled. The sizes are governed by the journal dimensions and only 5 x 9 in. or "C" axles and 5½ x 10 in. or "D" axles are used.

When axles are being charged, they are unloaded onto a portable rail bed which is set in front of the inclined conveyor bed to the furnace charging roller table. This portable bed holds only one row of axles and the axles are rolled down to this inclined conveyor, and thence to the furnace charging table. The axles are charged into the furnace in two rows.

The inside measurements of the continuous reheating furnace are 17 x 46 ft and the maximum billet length is held to 15 ft-3 in. The furnace is end charged and side discharged, and is of the two-zone heating type: a preheat zone and a soaking zone. The furnace is end fired using either natural gas and/or No. 6 Bunker "C" oil. There are eight burners at the end of the furnace at the lower level for the soaking zone and seven burners at the higher level for the preheating zone. These burners are capable of delivering 48,000,000 Btu's per hour. The furnace is equipped with automatic temperature control equipment. The furnace may be controlled automatically or manually at the discretion of the operators. The billets or axles move over six silicon carbide skids for approximately two thirds of the furnace length and over the last third of the furnace on a chrome ore hearth, or soaking zone.

The billets or axles are discharged from the furnace by means of a peel driven by pinch rolls. The bottom pinch roll is raised by an air cylinder to grip the peel to the top driven pinch roll. As the billets leave the furnace, an air cylinder lowers the top discharge pinch roll, and delivers the bar onto a roller line. From this roller line, the bar is pushed onto a bed by a conveyor chain which transfers the billet to the front 20-in. mill roughing table.

The three-high roughing mill rolls are designed for one, three, five or seven passes, depending upon the billet sizes and sizes of finished products. This roughing stand, driven through a gear reduction unit with a ratio of 4.025 to 1 through 19-in. pitch diameter pinions, holds rolls of 72-in. body length usually pitched to 20½-in. maximum and 18-in. minimum diameters. The three-high pinion stand is of fabricated steel and the pinions are lubricated by pressure system. This is a

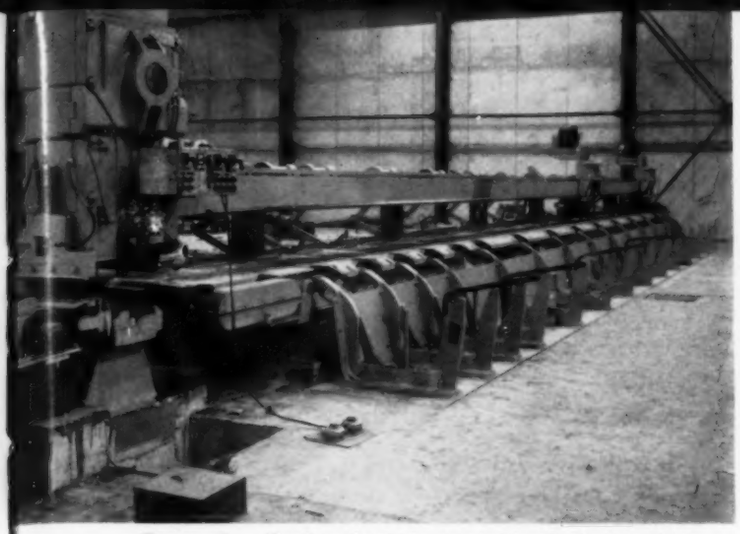


Figure 4 — Cooling bed shear and back shear tables.

Figure 5 — Hot bed is 250 ft long and 21 ft wide.

system with a large tank located under the hot bed. The oil is fed to the pinions by a centrifugal pump and the return to the main tank is by gravity. The pinions for the 12-in. mill are lubricated in the same manner from a tank located beneath mill floor.

This roughing stand is a steel fabricated housing and is serviced by a 5-ton, single hoist, overhead crane, with a span of 47 ft-3 in. This crane capacity is being increased to 15 tons. With this capacity, all three rolls will be removed at one time and preset rolls in a rack on the adjacent mill floor will be lowered into place in the housing. This will cut changeover time on the mill to a minimum.

The front roughing mill table, which can be raised or lowered to match various diameters of rolls, works in conjunction with the back mill tilting table. The front mill table enters the bar between the bottom and middle rolls on the odd number passes. The back mill table enters the bar between the top and middle rolls on the even number of passes. Both tables are operated by one operator in a pulpit located to one side above the three-high roughing mill. The front mill table and hydraulically operated back mill table are line-shaft driven by mill type motors and reduction set, and are 37 ft-0 in. in length. All table rolls and the line shafts of the front and back mill tables are equipped with tapered roll bearings which are greased by a centralized manually operated pressure greasing system.

When axles and the large size billets were being rolled, the short and heavy cross section of the bar being delivered from the second pass presented handling problems on the front mill tables for entry into the third pass. Therefore a "dump table" was designed, 24 ft in length. This "dump table" is anchored to the front mill table and positioned in line and at the right height to receive the bar as it is delivered from the second pass. The bar is delivered in a straight line onto idler rolls of the dump table. The entire dump table works on a cam operated by an air cylinder which lowers the table and then tilts the table so that the bars are "laid" into position for entry into the third pass. This table eliminates the handling of bars and the necessity of turning the bars by hand into the next pass.

At the delivery end of the back mill tilting table, to one side, an "A" frame hot bed has just been installed replacing a flat rail type hot bed to accommodate sections finished from the three-high roughing mill. This hot bed is 40 ft in length and will hold 26 bars with a cooling rate of 80 bars an hour. From this hot bed, the bar will be discharged onto a driven roller line running back towards the three-high roughing mill and parallel with the three-high roughing mill tables. This roller line will be extended into the finishing department to a shear where the bars will be cut to length. From these shears a driven roller table will transfer the bars to a cradle for stacking or to a straightener for machine straightening. This straightening machine is designed with eleven vertical rolls and horizontal rolls and will straighten bars up to a 3 in. square. This equipment will give the mill even more flexibility in its planned range of standard and special sections.

The distance from the 20-in. mill back tilting table to the No. 1 12-in. intermediate stand is 160 ft. The bar from the 3-high roughing mill is usually delivered to the No. 1 12-in. intermediate stand by a table divided into two sections and spanning this gap of 160 ft. When the bar requires six passes beyond the three-high roughing mill and is delivered to the No. 1 12-in. intermediate stand, the two sections of the table are in line with each other. When only four passes are required beyond the 20-in. roughing mill, the front section of the table is pivoted to deliver the bar to the No. 3 intermediate stand. This section of table is also in this position for delivery of bars from the 3-high roughing mill to the aforementioned "A" frame hot bed. The rolls on both sections of tables are driven individually by geared motors.

Future plans also call for additional 2-high non-reversing breakdown stands in this 160 ft area to give the mill even more flexibility and range. The foundations for these future stands were installed during the building of the mill.

The six stands of the 12-in. cross country mill normally house 12-in. rolls, but by changing the "furniture" of the housing, ten-in. rolls may be used. The first two stands house 30-in. body length rolls; the last four stands 24-in. body length rolls. Although the leader and finishing stands may readily be altered to house 20-in. body length rolls, the pinion stands for the leader and finishing stands are designed also to accommodate 10-in. pinions, if so desired.

The housings are of cast steel and of husky design

with removable caps. A complete complement of spare housings for "build up" on the mill floor adjacent to the mill has been provided to facilitate roll changes. The mill and build up area are serviced by a 15-ton single hoist, overhead crane with a span of 89 ft.

Entry and delivery rest bars are interchangeable with simplified guide box design to speed setups and changes. The guide boxes are anchored to the rest bars by a steel wedge instead of being bolted as is customary. These wedges are easily inserted and removed which speeds up pass changes.

On the entry side of each roll stand are located air-operated bar turners operated by means of an electric eye through solenoid switches. These bar turners are designed to operate through an arc of either 45 or 90 degrees. These bars are transferred from stand to stand by five reversing tables for the heavier sections, or by five repeaters for single or double-strand repeater operating on the lighter sections. These reversing tables are all lineshaft driven by mill type motors through reduction sets. All line shafts and table rolls are equipped with roller bearings which are greased by a manually-operated pressure greasing system. The lengths of these tables ranging from 1 to 5 are 79, 91, 115, 156 and 200 ft.

The reversing tables are not equipped with skew rollers normally employed in mills of this type, which move the bar laterally from one stand to the next. Instead, the reversing tables in this mill are only equipped with straight table rolls and the bar is pushed across the reversing tables by a sweep arm which lines up the bar for entry into the next stands. These sweep arms, pivoted on one end, are motor driven through a reduction set and crank arm and are controlled by the operator who also controls the reversing tables. There are two operators located in pulpits, one on each side of the mill, who operate the tables and sweep arms on their respective sides. That is, one operator operates tables 1, 3 and 5, the other operator operates tables 2 and 4 on delivery side of stands 2 and 4, plus the 160 ft run-in table from the three-high roughing mill to No. 1 intermediate stand.

This type of table and sweep arm arrangement has two distinct advantages over the conventional skew table: one is that the bar is under better control for reversing; the other advantage is the lower maintenance cost as compared with skew type tables.

The repeaters repeat the bars from one stand to the next on all six stands. These five repeaters are always in location whether repeating takes place or not. The repeaters are in a casting mounted on slides and these castings can be moved laterally by hydraulic cylinders to line up with the passes to be used. The repeaters are of the double channel jump type for single or double-strand repeating. A recent innovation has been the installation of automatically operated flippers mounted in the entry side of the repeater castings to help the loop "break out" and to hold the loops out of the repeater troughs. The double repeaters are on 78 ft-8 in. and 8 ft-3 in. centers. To date only single strand repeating has been done on the smaller rounds, reinforcing bars and flats. Bars will be double strand repeated at a future date. The repeater castings are so designed that for reversing table operation they are moved laterally on their ways to line up a trough

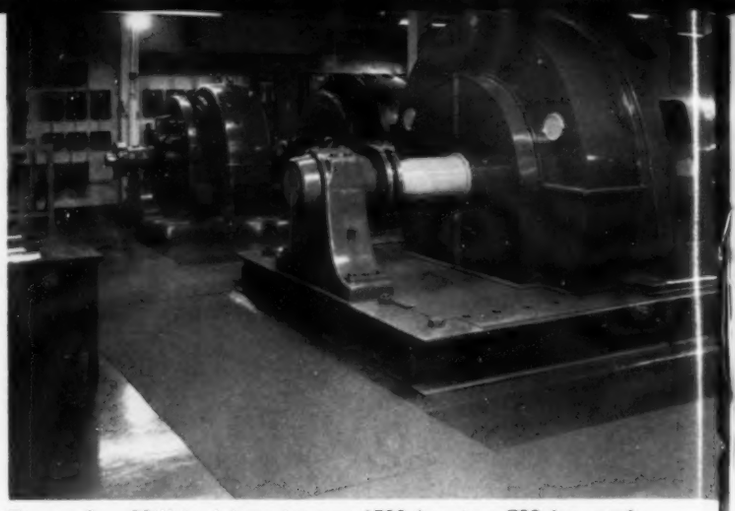


Figure 6 — Mill is driven by one 1500-hp, two 700-hp, and two 600-hp motors.

through the repeaters to the reversing tables. The aforementioned bar turners are mounted on the repeater castings and are automatically positioned to line up with the correct passes. The arrangement of this design is very advantageous in that the repeaters are always in place, thus minimizing the setup time when changing from reversing table operation to repeating operations and vice versa.

The roll stands are in staggered arrangement, and the six stands are driven by four motors and pinions. The centerlines from pinions to stands and from stand to stand are as follows:

Pinion to No. 1 stand	7 ft-¾ in.
No. 1 stand to No. 3 stand	16 ft
Pinion to No. 2 stand	14 ft-1¾ in.
No. 2 stand to No. 4 stand	16 ft
Pinion to No. 5 stand	7 ft-6¾ in.
Pinion to No. 6 stand	12 ft-6¾ in.

The bars are delivered from stands 1, 2, 3 and 6 between spindles and these spindles are supported by spring loaded carrier bearings, mounted in pedestals. The spindles are 4½ in. outside diameter x 3 in. inside diameter, cold drawn, seamless tubing and the stands and pinions are coupled with coupling boxes and four pod wabblers.

On the delivery side of the finishing stand are located motor driven double flying shears with air-operated clutch and brake. Either shear is capable of cutting up to a 1-in. square. Each flying shear is electrically coupled to the mill delivering speeds to cut bars to desired hot bed lengths. The finishing stand speeds range from 620 to 2100 fpm.

Following the flying shears are two mill run-out tables which deliver the bars to the hot bed run-in tables, these four tables are mounted one above the other for handling one, or two bars simultaneously if needed. All of these table rolls are individually driven by direct-drive motors with a range in speed to handle the delivery speeds of any bars.

The hot bed is a single sided flat bed with notched bars and is 250 ft long and 21 ft-0 in. wide. The bars are delivered to the hot bed and are kicked off automatically by the use of insulated rolls or electric eye which in turn operates, through a timing device, the hot bed notch bars. Thus the bars are kicked off and carried across the bed automatically eliminating the

need for the conventional hot bed operator. After leaving the notch bars, the rolled bars are deposited on shuffle bars which are individually driven by gear type motors. All manually-operated controls for the hot bed are located on the shear control panel and may be operated by the shear operator. With the exception of the shuffle bar eccentric, all bearings on the hot bed are greased by manually-operated pressure greasing system. The 150-ton single sided shear located on the end of the hot bed run-out table holds 30-in. blades and is capable of cutting up to two flats 4 x 1 in. or their equivalent. The shear is belt driven and is equipped with an air-operated clutch and brake. The back shear table is equipped with motor-driven kickoffs and two electrically operated shear gages for handling cut lengths up to 60 ft-0 in. The shear cradles are mounted on a scale for weighing the bars after shearing. This shear has a capacity of 26,250 lb. The back shear table rolls are individually driven by gear motors. The shear and last 75 ft of hot bed are located in a new modern warehouse of two parallel bays, each 508 ft long, covering an area of 81,000 sq ft. Each of the two bays is serviced by two double hoist, ten-ton cranes with 78 ft-7 in. spans. The warehouse is at right angles to the mill and one end extends slightly beyond hot bed and mill shear in one direction. The inside bay of warehouse crosses over approximately 75 ft of delivery of hot bed. The outside bay crosses over mill shears.

Crossing the warehouse in the center is a double truck dock handling four trucks (100,000 lb) and truck scales for truck shipments. Parallel to this truck dock are two railroad sidings holding four railroad cars at a time for rail shipment. A 150-ton railroad scale is located on the outside of the warehouse. A gasoline-powered carmover switches cars in and out of warehouse.

Additional equipment located in the warehouse are two angle straighteners, two round straighteners and the aforementioned new straightener for handling flats and special sections.

To date only standard sections have been rolled, but special sections are now being contemplated. The range of products presently being rolled are $1\frac{1}{2}$ x $\frac{5}{16}$ to 4 x 1-in. flats, $\frac{5}{8}$ to $2\frac{1}{2}$-in. rounds, No. 5 to No. 11 rebars, and $1\frac{1}{2}$ x $1\frac{1}{2}$ to 3 x 3-in. angles. All the above sizes have been rolled from billets and the following sections have been rolled direct from axles; No. 8 to No. 11 reinforcing bars and 3 x 3 x $\frac{1}{2}$ and 3 x 3 x $\frac{5}{8}$-in. angles. Smaller sizes of rebar and rounds will be rolled with the addition of the aforementioned roughing stands between the three-high roughing mill and 12-in. intermediate stands. Provisions are now being made to roll the smaller sizes of flats to 1 x $\frac{1}{4}$ in. and angles to $1\frac{1}{4}$ x $1\frac{1}{4}$ in.

The installation of the mill necessitated new and expanded service facilities. To this end, a modern metallurgical department and expanded roll shop were provided. The metallurgical department is equipped with full chemical facilities for analysis of all types of iron and steel; with a hydraulic tensile machine, Rockwell and Brinell hardness testers, and with microscope and polishing equipment for metallographic examination. The laboratory is equipped with saws, lathe, grinders and drills for preparation of chemical and physical test specimens. The department's functions start with the inspection and the coding of incoming billets and extends to physical and chemical analysis, as well as the physical inspection of the finished products.

The roll shop is equipped with one combination eight-10-in. and 12-in. tandem roll lathe, one 14-in. tandem roll lathe, one 36-in. heavy duty engine lathe, one 28-in. roll lathe, one 14 x 50 in. horizontal roll grinder and one 10-in. dual tool grinder. The roll shop is serviced by a 5-ton overhead crane with floor and hand controls. All rolls to be dressed or turned are stored in the roll shop in three 6 x 4-high roll racks. The 12 and 10-in. roll storage area is located outside the roll shop and parallel to the 12-in. mills. These rolls are stored in five 22 x 4-high roll racks. All chipping and grinding and ragging is done in the roll shop.

The mill is compact in arrangement and it can be changed from one section to another quickly; it finishes at relatively high speeds.

The following features are incorporated in this mill:

1. Finishing of sections on roughing mill.
2. Built-in repeaters and quick changes from reversing to repeating operation, and vice versa.
3. Permanently positioned bar turners on all 12-in. stands.
4. The abolishment of skew tables and the use of sweep arms.
5. The use of hydraulic power for movement of repeater castings.
6. Interchangeable rest bars and manner of anchoring guide boxes.
7. Automation of hot bed.

DISCUSSION

PRESENTED BY

DAVID POLLAK, Vice President, The Pollak Steel Co., Marion, Ohio

HUGH H. CAMPBELL, Manager of Manufacturing, Steel Div., Phoenix Manufacturing Co., Joliet, Ill.

ALBERT F. RUPP, Superintendent 10-In. and 14-In. Merchant Mills and P. C. Dock, Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.

NORMAN SOLOMON, Roll Design Engineer, West Virginia Steel & Manufacturing Co., Huntington, W. Va.

CARL W. LARSON, Superintendent Roll Shop, Phoenix Manufacturing Co., Joliet, Ill.

E. C. PETERSON, Vice President, Rolling Mill Equipment Div., Birdsboro Steel Foundry and Machine Co., Birdsboro, Pa.

David Pollak: There are certain problems involved in operating a small steel mill which make the operation more complex than that of a large tonnage mill. The justification for the existence of a small steel mill is based, to some extent, upon its ability to be flexible. Frequent section changes are the very lifeblood of a small mill operation. The large mills, in most cases, require fairly large tonnages before they will roll a section, but the smaller mills, many times, will roll 100 tons or less and then change rolls or passes. It is for this reason

that their production must be geared to great flexibility and rapid changes.

The second thing that adds to the complexity of operations of a mill such as this is the fact that there is frequently lack of uniformity in raw material. Where the larger mills will use standard sized billets, a small, non-integrated mill must acquire its raw material whenever it is possible of necessity, therefore, must use a greater variety of sizes and types of raw materials. It is for this reason that axles become a primary source of raw material for Phoenix.

As was evident in this paper, a large amount of money has been spent and, of necessity, it had to be spent wisely and the maximum had to be obtained from these expenditures. Now, that is true of every mill, but a millionaire can afford to lose $100.00 in a poker game more easily than a man on a $5000 a year salary. While this may not be a fair comparison, it is fair to say that no small mill can afford very many mistakes in any of its installations.

Added to this is the necessity for a great amount of ingenuity in construction, such as was indicated, for instance, in the installation of the repeaters which were mounted on slides so that they could be moved laterally by hydraulic cylinders in order to line up with the passes to be used.

The entire repeating operation as explained has a great deal of interest because, again, it allows for quick removal of repeaters to let the bars run out, and also allows for double strand repeating in the future.

The rolling of axles poses a problem both in the rolling and in the heating, and I might ask Mr. Campbell how Phoenix prevents the axles from rolling on the furnace skids and, secondly, is it necessary to remove the dust collars before rolling?

Hugh H. Campbell: First, on how we prevent axles from rolling in the furnace, as has been explained, the axles are charged into the furnace in two rows and both rows are first pushed through the furnace by means of a single ram driven by an eccentric and reduction set. The furnace bottom has a pitch of 1 in. in 12 in. for the first forty feet, and then levels out on the hearth.

Originally, the furnace was installed with refractory type skids, but to reduce friction, these were removed, and then replaced with steel skids. These steel skids are four by four in., set on the diamond and extend from the charging roller line to the hearth. The skids were so placed in the furnace so that the axles would ride the skids on the wheel seats.

To prevent rolling and piling, four holddowns were inserted into the furnace, two each on top of the axles. These holddowns are anchored to a cross piece at the charging end of the furnace and their combined weights prevent piling. These holddowns are 24 ft-6 in. in length, and are four by 12-in. slabs. As the axles leave the holddown, they are hot enough so they push without piling and rolling.

The axles are charged so that the inside shoulders of the wheel seats line up and these are the pushing parts. This does not prevent an occasional axle piling, but it has been very successful for us. The mill has just finished rolling a total of 12,500 axles and very little difficulty was experienced.

As for your second question, is it necessary to remove the collars from the axles before rolling, originally the collars were removed by burning torches but the installation very recently of cropping shears in the mill has been successful and the removal of these collars before charging has been discontinued.

Albert F. Rupp: I would like to pose some questions: (1) would you like to give a little more information on the detail of the sweep arms; (2) what is the construction; (3) would you explain the operation of the flipper; and (4) how many people are on the force?

Hugh H. Campbell: In answer to your question on the detail of the sweep arms; the five sweep arms are all identical and interchangeable. They are made from 8-in. wide flange beams and their weight is carried by a roller which rides the apron plate of the reversing table. The amount of sweep is controlled by the crank arm which in itself is a turnbuckle arrangement. The crank arm may then be extended or contracted so that the sweep arm will line up with any pass desired.

The sweep arms are 25 ft in length and are driven by a 5-hp, 220-volt, d-c motor.

As for your question pertaining to the operation of the flippers in the repeater troughs, these flippers are raised by air-operated cylinders, through solenoid switches activated by electric eyes set in the preliminary chutes on the entry side of the next stand. As the bar enters the next stand, the flippers raise the bar out of the repeater trough and prevents knuckling. The loop is allowed to grow to drop over a turtle back located on the reversing table and this prevents bar from dropping back into the repeater troughs.

As for the operating force, from billet storage to shipping, including salaried personnel, it is 38 men per shift.

Norman Solomon: What type of pass design do you use in your 20-in. mill for breaking down your C and D axles, and what type of ragging do you use in these passes?

Carl W. Larson: The breakdown for our axle roughing set comprises five passes and finishes with a $2\frac{5}{8}$-in. square from the fifth pass. These squares may either be continued to the 12-in. mill for direct rolling or may be discontinued after leaving the roughing stand and transferred to an adjacent hot bed and stored for re-rolling as billets. The pass sequence for this set is box to oval to square to diamond to square.

As the area of contact from the axle to pass 1 is very small, a need for ragging is required to pull the axle into the rolls. Tbis also aids as a scale breaker. Pass 2, oval, is also ragged slightly on the sides for the same reason as pass 1. Pass 3, square, requires the greatest amount of ragging as the reduction in this pass is bigh and much slippage is incurred. The type ragging used is the "D" type or ovaloid in shape. Passes 1 and 2 are ragged approximately $\frac{1}{8}$-in. deep and pass 3 is $\frac{3}{16}$-in. deep.

Passes 4 and 5 are pepper ragged or roughed up to keep slippage at a minimum.

E. C. Peterson: There has been some discussion of the tables, which are of a new design, and I would like to say a few words about them.

The separate run-out table, with chain transfers to another approach table is the conventional way of transferring from one stand to another. It is probably the most flexible method available, but it is very expensive, and is not always required.

Another solution that has been used is the standard

skew table, which is relatively inexpensive, but it has its limitations. For one thing, when working with bar turners, flat ovals when approaching the turner will be forced to roll, which makes it rather difficult to get it into a mechanical turner. Second, there is a lot of wear at the ends of the rollers and they wear away rapidly. Third, it is necessary to run the bar pretty far back from the mill to get transfer on a skew table, so that time is lost in transfer.

The tables at Phoenix are very little more costly to build than standard skew tables but the principal disadvantages of the skew table are eliminated. Another interesting method of transferring bars is shown in Figure 7. This is a view of another recent bar mill installation, and the last two stands that are seen in this view are serviced by bar-turning transfers; they consist of a long trough pivoted at the back and traversing at the front end. The transfer mechanism includes a set of air-loaded and motor-driven pinch rolls, which also act as bar turners.

The repeater was discussed at some length and Figure 8 gives more detail. The repeater is shown with the trough that Mr. Campbell mentioned for straight work. This figure also shows an interesting variation on the mill for which the repeater shown was made. The bars are produced by the flat-edge-oval-round method. The flat has to be cropped, so that hydraulic shears have been mounted on the same base with the repeater and bar turner, and the bars are cropped before turning up for entry. The rotary drum flying shear has several advantages, one of them being that the bar does not have to be diverted for cutting; working small bars at high speed is not easy to do successfully under the best conditions, and cutting straightaway makes the easiest method. However, speeds in modern bar mills have gone above the practical limit of the direct electrically-driven shear. In a recent installation made in a bar mill in the mid-west, such a shear had a 100-hp, d-c motor with variable voltage control.

Another installation made by our English correspondent has two 100-hp motors, and is being successfully operated at 2000 fpm, but the electrical cost of such an installation is quite significant.

Furthermore, in approaching the practical speed limits of the direct-driven shear, we can put a bigger motor on it, but we just do not get more speed out of it. The motor can not accelerate itself fast enough, let alone a shear. For this reason, the present type of shear was designed. This shear, by changes in its mechanical arrangement, can be designed to run at speeds in excess of 2000 fpm.

The air-operated friction clutch and brake is a very interesting new development; it has also been used recently on stationary shears. Mr. Campbell mentioned that the cold bar shear at Phoenix is so operated. We are using this method of drive successfully on most of our recent shears and a picture of it was shown.

Figure 9 shows a 500-ton bloom shear, which has been equipped for this type of drive. The advantage of this drive as compared to the start and stop d-c drive is the lower overall cost of the entire shear, including electrical equipment, and as compared with the standard jaw clutch type, the shock of engagement is eliminated together with much maintenance. If the air supply is properly regulated it provides a very efficient safety device in case the shear is overloaded.

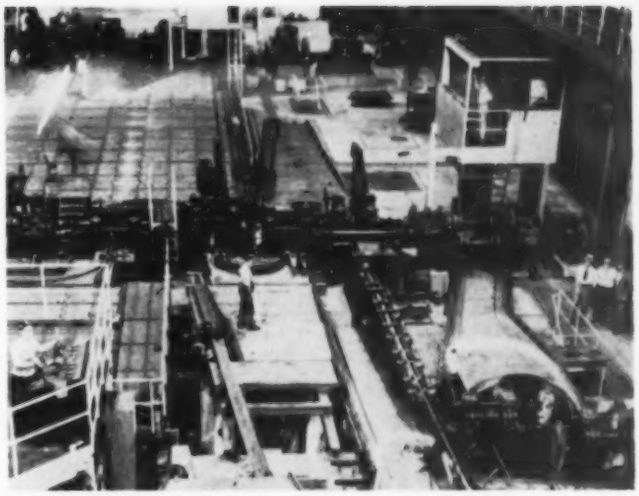


Figure 7 — Transfer mechanism on this mill has a set of air-loaded and motor-driven pinch rolls which also act as bar turners

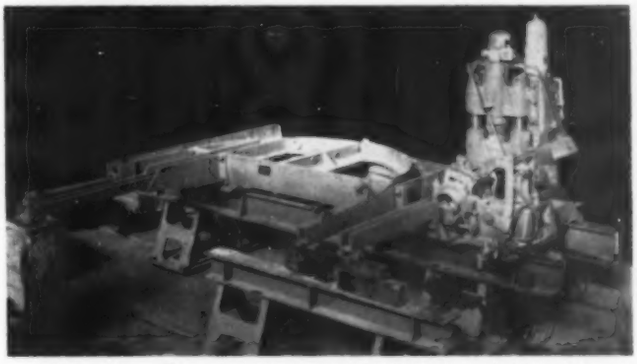
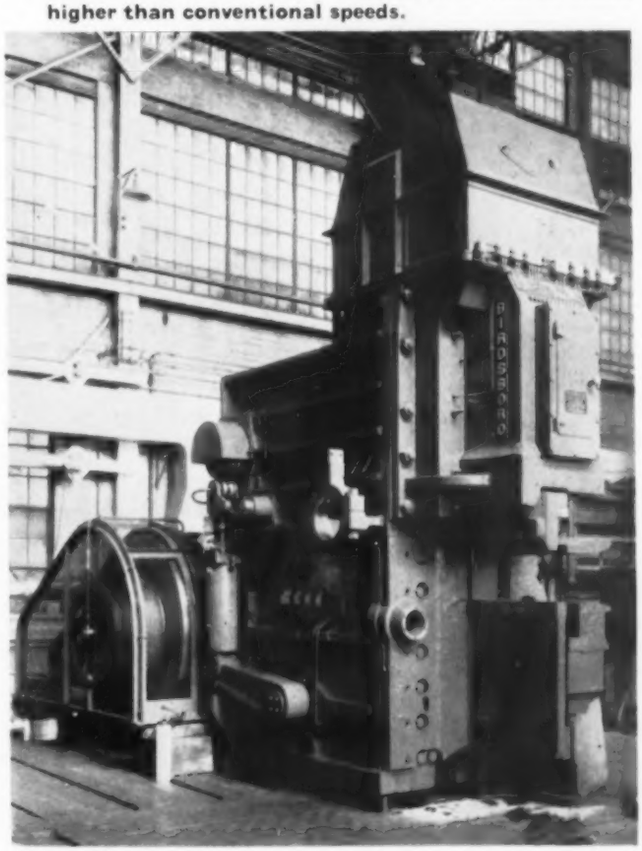


Figure 8 — Repeater has a trough for straight work.

Figure 9 — This 500-ton bloom shear has an air-operated friction clutch and brake enabling it to run at much higher than conventional speeds.



By P. D. THOMAS
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PIPE—MANUFACTURE AND USE

. . . . it is up to the ingenuity and application of the steel plant engineer to visualize, build and put into operation the new mills and processes which will be necessary to satisfy the increasing demand for better pipe . . . .

▲ PIPE has come to be most intimately associated with many phases of life today—with industry, home, health and science. Industry is now in a period of pipe shortage accentuated by the constant development of new outlets (for example the pipeline to carry coal from the Ohio River to Lake Erie), by expansion of existing uses, and by constantly changing quality demands for pipe with higher strength and with greater resistance to corrosion and to both higher and lower temperatures. This is the time to appraise the future!

Sales, field, developments and metallurgical engineers who know the pulse of development in their respective fields can point out what is going on, and these men have individually and collectively done excellent work in this regard. However, the reactions behind the managment lines to their information and warnings have on many occasions seemed to the customers to be painfully slow and—as a result—both over-all pipe tonnages and, particularly, the tonnages of tubulars requiring special production facilities have, in many instances, fallen appreciably behind demand.

PAST DEVELOPMENTS

There is no record in very early history of who first used a reed or a hollow log to move water from here to there but, whoever he was, this genius ranks as the discoverer of pipe and this feat of his budding brain power started a chain of events that has led from pipe being just something handy with a hole through it, to the multiplicity of pipes, tubes and tubing in use today. We know that the Egyptians circa 2800 B.C. used hammered copper pipe, that the ancient Chinese used bamboo pipe, that the Babylonians used copper and tile, and that about 1500 B.C., the Cretans had elaborate piping systems for domestic water, drainage, bathing and sanitary facilities. The Romans used lead pipe and made extensive use of aqueducts, while the Incas had water courses to bring water for domestic and sanitary purposes. These water lines were the ancestors of the complicated systems of water, oil, and gas transmission of today.

The first pipe shortage probably occurred when one of man's hairy, hoary ancestors ran out of reeds in his own patch and forthwith picked up a few hides or a war club and went, commercially or militantly, to visit a neighbor. Throughout early history there were constant peaceful commercial and intermittent military interchanges which involved metallic ores, and the flatlanders were always visiting or attacking the mountaineers to get metals, minerals, precious stones and building rock. There is even a Sumerian tablet describing a "war of nerves" to get certain building essentials. It is not unlikely that after smelting some of these metals, copper and lead for example, were used for making pipe, as transportation of water was a very essential operation in the economic life of those times. These early beginnings saw man making more and more use of tubular sections, spurred on by both domestic and military demand. The Arabs in the 1100's A.D. had musket barrels made of iron. In 1687 the French cast iron cannon barrels and this was soon followed by casting iron pipe for water service.

DEVELOPMENT OF MODERN PIPE MANUFACTURE

A. Buttwelding—The success of Murdock's idea (1815) of using surplus musket barrels for transporting gas to light a street in London set up a strong demand for pipe that soon exhausted the gun barrel supply and thereby triggered the invention in 1825 of the conventional buttwelding method, a process which, with some modifications, still produces about 40 per cent of the buttwelded pipe or 10 per cent of all the tubular products rolled in this country today. In the 1850's the single-bell was designed and superseded the original double-bell method of buttwelding. At first wrought iron was used exclusively, but in 1887 the first steel pipe (bessemer) was successfully buttwelded. In the 1920's large tonnages of rephosphorized open hearth steel were buttwelded and very early in the 1930's, production of rimmed low phosphorous open hearth steel buttwelded pipe was begun. These latter changes were made in response to quality demands from several large segments of the pipe trade.

A big improvement was made in weld quality by the use of an oxygen blast on the edge of the skelp as it entered the welding bell. The extra heat generated on the welding edges by the oxygen resulted in very strong welds, and several mills produced buttwelded tubing suitable for redrawing by sinking. This development hinged on a demand for this product primarily from the automotive industry.

Conventional buttwelding is a rapid and most fascinating process to watch, but in 1923 the Fretz-Moon method was patented and this highly mechanized development, now usually known as "continuous buttwelding," is even faster, with markedly higher production in sizes 1¼ in. and over. Originally used for the sizes under ½ in., it now encompasses all sizes up to 4-in. nominal (4½ in. outside diameter) as against the ½ to 3-in. range of the conventional buttweld. It makes welds of good quality, aided by an air-jet on the skelp edges as the skelp comes in a continuous ribbon from the furnace. The expansion of this process has enabled the manufacturers of buttwelded pipe to meet today's heavy demands for this product.

Buttwelded pipe has a strong place in today's market. In home and building construction, it is the most economical type for carrying gas and water, although steel is not satisfactory for aggressive soft waters. It is extensively used in rigid conduit for carrying and protecting electrical wiring. It has a multitude of uses in refrigeration, in cooling and heating coils, and in mechanical uses, such as wheelbarrow handles, where it must stand severe bending. Buttwelded pipe has its field, in that field it is economic, and if properly made it will perform well.

B. Lapwelding—There was one outstanding drawback to the early buttwelding operation—the upper size limitation! The early manual hammer-lapwelding process had been invented in 1812, and in the 1840's this process was mechanized by rolling down the lap by means of a ball placed between the rolls of a 2-high mill. From then until the 1920's lapwelded pipe was the main process in the pipe world in sizes over 3 in.

In the 1920's, seamless pipe began replacing lapwelded, particularly in oil country tubulars, and the decline of the lapwelding process was hurried along by the advent of electric welded pipe which began to take over the linepipe market and even to encroach on the oil country tubular goods market. Thus by 1940, lapwelded pipe found itself relegated to the relatively minor position it holds today, though there is still a good market for it as water and gas pipe. Over a period of time lapwelded pipe has served well, but under the market conditions prevailing in recent years, it has had many uses that might not be continued under a state of balanced supply and demand.

C. Pierced seamless pipe—Inventors early conceived the idea of a pipe made from solid bars and envisaged the advantages accruing from a weldless tube. An extrusion process for making seamless pipe was patented in 1836 and the course of progress is seen in the extensive development of extrusion in recent years. There were numerous other inventions, such as cupping, but the key development leading to the production of seamless pipe as we know it today was the invention—or was it an accidental discovery—of the rotary piercing process by the Mannesmann brothers in Germany (1886). This operation took the important first step of getting a hole through a solid piece of steel, and subsequent developments have been directed toward changes in the piercing mill and toward rolling the pierced shells into better finished tubes. In Europe this latter development has proceeded mainly along the line of pilger mills and in this country along the line of automatic mills.

The first incentive for bringing the seamless process to this country was the very heavy demand for bicycle tubing in the 1880's and 1890's, and in 1891 the first seamless tube mill in the U.S.A. was built at Shelby, Ohio. Within a few years this country changed from an importer to a net exporter of cycle tubing. There were some rough days ahead of the industry as the demand for cycle tubing fluctuated widely and prices sagged or jumped along with the demand.

The next big shot in the arm was the growing requirements in the 1920's for higher strength casing, tubing and drill pipe by the rapidly expanding oil industry, and most of the large pipe manufacturers as we know them today built seamless tube mills, in all but a few cases automatics. The tonnage produced by these mills soon eclipsed all other seamless production, and their versatility has enabled them to roll a wide variety of carbon, alloy and stainless steels into pipe, tubes and tubing. For example, API Grades A,B and some of the X grades of line pipe, and H-40 and J-55 casing and tubing can be rolled directly off the mill as hot rolled product. By means of auxiliary heat treating equipment, Grades N-80 and P-105/110 tubing and casing can be produced. Proper heat treating equipment also makes it possible to produce the chromium, chromium-molybdenum, and chromium-nickel heat- and corrosion-resistant steels that are widely used by the petroleum refining, chemical and power industries.

D. Electric-welded—During the 1920's electrical methods of welding were studied and some pipe with fusion-welded seams were produced. In 1933 production of electric resistance welded pipe was begun and soon this process, with many arguments at first as to its quality and rating, was well under way.

Electric welding may be divided into three main classes: (1) electric resistance welding, (2) flashwelding, and (3) submerged-arc welding.

The principal advantages associated with electric welding methods are the wide ranges of diameters, uniform light walls, and the variety of carbon, alloy and stainless grades that can be welded.

It is in line pipe that the electric welding processes have found their largest market. Aided by hydraulic or mechanical expansion, they have taken the weldable range of approximately 0.22 to 0.27 per cent carbon, 1.00 to 1.20 per cent manganese steel and built it into the API Standard 5LX Grades for the high pressure oil and gas transmission lines of today, in sizes up to 36 in. outside diameter and probably larger in the future. With the amount of gas and oil to be moved over long distances, and the desirability of trunk lines being constructed in other parts of the world, this large outside diameter product, while at times somewhat elastic in demand, has a very important place in future developments, both economic and strategic.

E. Other methods and products—(1) Extrusion: The subject of extruded pipe could logically have been included in the seamless category but this process, imported from Europe, is new on the American scene. Some 120 years after the first patent application for an extrusion method, it has developed here into a commercial process that produces tubes up to 22 in. outside diameter and makes itself felt in the production of heavy wall and high alloy tubing grades, many of which are very difficult to pierce by the normal methods. Extrusion is also working out well in the production of such

nonferrous tubes as titanium, zirconium and molybdenum, which hold promise of wide and successful use in highly corrosive chemical operations, atomic power and high temperature operations generally. Extruded pipe is coming into the market when demand for high alloy steels is at its peak and when a wide vista of nonferrous alloys is opening up.

(2) Aluminum: The light weight and corrosion resistance of aluminum have made its use attractive in line pipe and other services where quick, easy handling is also important.

(3) Plastics: Plastics must be considered as tubular materials, (both as the extruded pure plastics and as fibre-reinforced plastics) and also as linings for oilwell tubing and line pipe to resist corrosion and the deposition of paraffin. Plastic pipe manufacturers have been going through growing pains. Extensive development work is well under way to solve many of their problems and encouraging progress has been achieved. Standardization of manufacturing and testing methods, dimensions, and physical and mechanical properties is under way. Their full use cannot be predicted at this time, but plastic pipe should be considered as a supplement to steel pipe and as having a definite potential.

(4) Cast iron: Cast iron pipe still has a large market in this country, mostly in pipe for city water mains and plumbing, but also in some interesting applications of bi-metal pipe. Production in 1955 was 2,632,167 net tons (AISI).

THE TUBULAR MARKET TODAY

The foregoing section of this paper has been devoted largely to a summary of the history of the manufacture of tubular products, pointing out the development of production under the incentives of demands for quantity or quality. This next section deals with present day and future demands and the quality trends to be expected.

It is interesting to note that throughout the world tubular products, along with plates, are increasing in percentages of the total steel produced. In spite of that, we are now in a continuing period of pipe and plate shortage that has existed since World War II except for relatively minor breaks in 1949 and 1954. It is difficult to gage a market wherein demand is not being fully satisfied but production figures for 1955, Table I, do give a clue to the over-all market with respect to size, trends and the distribution of tonnages within that market. At present, tubular products represent about one-eighth of the steel products produced in this country and about one-twelfth of that in Europe. The difference between American and European tubular production lies mainly in the preponderance of tubulars produced here for the oil and gas industry; oil country tubular goods and line pipe represent roughly half of the total steel tubular production in the U.S.A. as against about one-fourth in Europe.

The total of casing, tubing and drill pipe production has climbed steadily each year since World War II, whereas line pipe tonnage has fluctuated, for example—3,500,000 net tons in 1953, 2,500,000 in 1954, and 2,750,000 in 1955. If the rate of production for the first half of 1956 continues through the last five months, line pipe production will reach close to 3,400,000 tons—with 1957 already sold out, 1958 apparently so, and many requirements holding over for 1959 and 1960 production.

The data in Table I also emphasizes the importance of the building industry—housing included—which through pipe for plumbing, central heating, electrical conduit, scaffolding and mechanical structural uses constitutes a very large consumer group for tubulars, particularly for buttwelded and lapwelded pipe. The power industry depends heavily on tubular products, and it and the processing industries are heavy users of carbon, alloy and stainless steel pressure tubes and pipe for processing and transporting liquids and gases, often at high temperatures.

Mechanical tubing, constituting one-ninth of tubular production in 1955, has found wide use in industry, from aircraft, automobiles and bicycles, to washing machines and furniture, from derricks and cranes to toys.

FUTURE MARKETS

A. Oil and gas—The demands of the oil and gas industries for tubulars in the American market will increase in the future and production for these industries should also become of greater importance to the European tubular industry. An ECE report states that the trends point to a continuing high and growing demand for oil country tubular goods for some years to come to keep up with an expected 5 per cent compounded annual increase in oil production. While annual demand for line pipe may vary, the economic and strategic importance of this method of transportation, the continuing expansion of the oil and gas industries, and the present supplies of gas still awaiting markets, point up

TABLE I
U.S.A. Production of Steel Tubulars, 1955, x Net Tons (Courtesy AISI).

	Oil country tubulars	Line pipe	Standard pipe	Pressure tubes	Mechanical tubing	Misc.	Total
Seamless	1,969,677	512,507	444,544	198,492	642,529	73,102	3,840,851 (38.4)*
Buttwelded	21,406	367,331	2,365,500	...	...	62,614	2,816,851 (28.0)
Lapwelded	8,703	95,893	163,028	...	...	...	267,624 (2.6)
Electric-welded**	461,057	1,675,551	277,546	75,194	480,597	...	2,969,945 (29.6)
Gas-welded	17,374	94,740	...	23,456	7,714	...	143,284 (1.4)
Total	2,478,217 (24.7)*	2,746,022 (27.4)	3,250,618 (32.5)	297,142 (2.9)	1,130,840 (11.2)	135,716 (1.3)	10,038,555 (100.0)

* Figures in parentheses are percentages.
** Importance of plate, and also strip, in the tubular picture is emphasized by the tonnages of electric welded tubular products.

continuing heavy demand for line pipe as well as for casing, oilwell tubing and drill pipe in the future.

The nature and the quality demands of tubular products will also change. In 1954 it was pointed out that while total tubular production might be adequate, there was a distinct shortage of heat-treating capacity to produce N-80 and P-105/P-110 oilwell tubing and casing, which were expected to exceed 50 per cent of total demand for casing and tubing by 1957. It is evident from the shortage of these grades today, that industry-wide production capacity of the heat-treated grades has still not caught up fully with the increasing demand, even though several manufacturers have greatly increased their facilities for these products and nearly all have increased their capacities to some extent. As long as the predominance in drilling activities remains in this country the increasing depths of wells will call not only for greater total tonnages per well, but also for greater production of the higher strength heat-treated grades of casing and tubing which will in turn be manufactured to more severe quality and inspection standards.

The line pipe situation will not be stationary. Higher strengths, while still using weldable steels, will be more than talked about and undoubtedly some interesting changes will be made.

Demand for tubes from the expanding refining, chemical and petrochemical industries and other new processes will also continue. These tubes will be called upon to withstand higher operating temperatures and pressures and to have greater corrosion resistance, and there will be more than passing interest in the possibilities of using tubes of titanium, zirconium, molybdenum and their alloys. Furthermore, some interesting low temperature uses of pipe are apparently in the offing.

B. Water—A large portion of the world lacks adequate facilities to transport water necessary for either domestic or industrial use and many modern cities must increase their supplies of water in the near future to meet the demand of growing populations and rapidly developing industry. The need for more water conservation systems, more aqueducts from dams and reservoirs to cities, more distribution systems to industries and urban and rural communities, and finally the need for more pipes in the homes and plants spell out continually increasing demand for pipe for water service in the future.

C. Construction—Construction is one of the largest markets for tubular products, which are used for providing water, gas, sanitation, central heating, and protection of wiring. This is a heavy market for buttwelded pipe in particular, but offers a wide opportunity for copper, plastics, and cast iron pipe and tile as well. The general increase in population, modernization of building designs in remote and underprivileged areas, modernization of homes already built here and abroad, and continued reconstruction of war-damaged homes in Europe appears to offer a continuing demand for pipe, although the rate of increase can reasonably be expected to diminish a little in the future in relation to what it has been in the past. Another item that may increase to appreciable tonnages is the use of tubular structural sections, as the tubular section has definite engineering advantages in lightness and strength.

D. Power—With increasing industry and more homes, and resulting demands for more power, which has been increasing at a rate of 4.5 per cent per year since about 1951, there should be increasing requirements for power plants. Already they are talking about 1350 F and 5000 psi—pressure and thus up will go the quality requirements.

E. Mechanical uses—Mechanical tubing production is tied to the level of other industries, and, with an optimistic outlook for these, a stable market should exist.

SUMMARY

It is apparent that in the future there will be a continuing increase in overall tonnage demand for tubulars. Accompanying this there will be demands for higher strength in oil country tubulars and undoubtedly in line pipe as well. In the power and chemical processing industries, there will be demands for steels with increased high temperature strength and greater resistance to corrosion. Users certainly expect the tubular mills to meet both the quantity and quality problems successfully, as they have in the past, although often, as pointed out, their reaction to changing demands has been too slow to suit their customers.

A growing part of the long range future market for tubulars may be found outside the U.S.A. and it behooves the American pipe industry not only to study this feature relative to American participation in the export market but also to seek firm establishment of American specifications, such as ASTM and API, as the basis of production.

Compliments have already been paid to sales, field, development and metallurgical engineers for their efforts to keep their mills abreast or ahead of customer's developments. High commendations are also due to the mill inspection departments by whose efforts the mills' troubles and problems are not allowed to slip through to the customer. With the further development of higher strength and higher alloy steels to meet increasingly severe requirements, inspection procedures must necessarily become more exacting, more technical and more mechanized.

DISCUSSION

PRESENTED BY

KARL L. FETTERS, Assistant Vice President, Youngstown Sheet and Tube Co., Youngstown, Ohio

Karl L. Fetters: I would like to pay a compliment to Mr. Thomas' research committee, of the API Division of Production, and the effort of all the people who have served on that committee, manufacturers as well as consumers, for having brought very early to the attention of the producers many of the problems which the consumers are facing in the field of higher strength and higher stress applications of tubular products.

There is a great deal of work which has gone on in recent years, and a great deal yet to be done in this field. The early efforts of this committee and these groups in the API have led to the present day production levels. Admittedly, there is not enough of the higher strength casing and tubing—and very little mention was made in Mr. Thomas' paper or drill pipe. However, all in the tube business are very familiar with the progress that has been made there.

Electrical Features of a Hot Strip Reversing Rougher

By
J. H. GREINER
Application Engineer
Electrical Application Dept.
and
A. MOZINA
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▲ IN 1951, Granite City Steel Company undertook an expansion program which included, among other things, additional open hearth capacity, a new 45-in., 2-high slabbing mill and new facilities for the roughing end of their 90-in. hot strip mill.

The roughing end of their hot strip mill, prior to 1951, consisted of a 3-high non-reversing mill with vertical rolls on the delivery slide, all of which were driven by a 3000-hp wound-rotor motor. Maximum slab thickness entering this mill was 4½ in. and the number of passes ranged from 9 to 13. Production was in the neighborhood of 80 to 100 tons per hour.

This mill, with its tilting table, was an ingenious device but because of limited capacity and excessive maintenance, it had to give way to new roughing equipment as the finishing train was not being used to capacity. A new continuous roughing train was out of the question because of cost, furnace capacity and property interference from the turbine plant and other facilities.

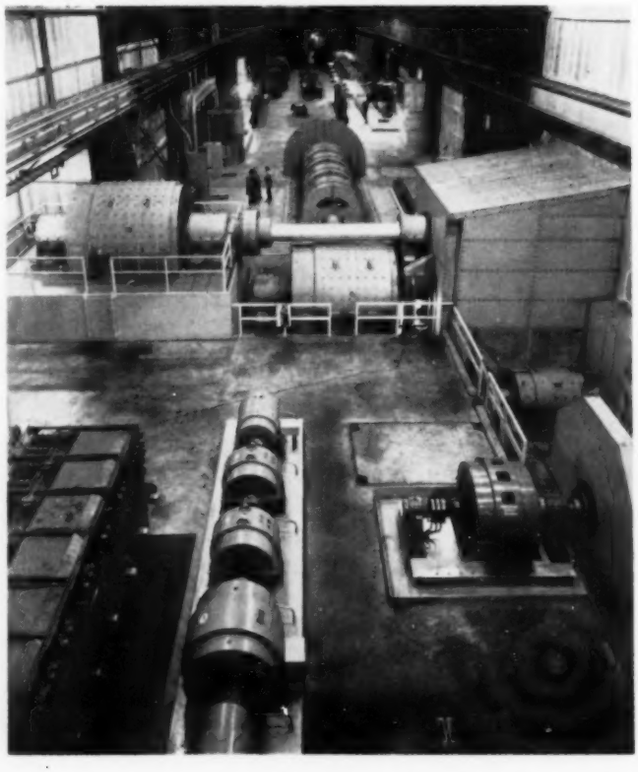
Consequently, a 4-high reversing rougher was selected and with it a close coupled vertical edger. Figure 1 is an over-all view of the revamped hot strip mill motor room. On the right hand side, in the foreground, is a 2-high roughing scale breaker which is driven by a 700-hp wound-rotor motor. Immediately behind it, and down in a well, is the vertical edger, which is driven by a 1000-hp, 250 to 750-rpm, d-c motor. The distance from this edger to the main mill is approximately 9 ft.

On the left hand side, in the foreground is the variable voltage auxiliary motor-generator set with control for the various tables and feed rolls adjacent to the mill. In the center is a 7000-hp, twin-drive motor consisting of two 3500-hp, 40 to 80 rpm, single armature, d-c reversing motors, which are direct connected to the mill spindles. Motor peak capacity is the standard 225 per cent frequently repeated value.

Beyond the main motor is the supporting 8000-kw flywheel motor-generator set with four 2000-kw generators. This set is a duplicate of the one used in the 45-in. slabbing mill which was installed at virtually the same time. A flywheel set was selected for the hot strip mill because of the light duty tie with the utility power system.

Figure 2 shows the operator's control pulpit. Offhand, it may appear that the operator is swimming in switches

Figure 1 — A 1000-hp, 250 to 750-rpm, d-c motor (shown in right foreground) drives the vertical edger.



. . . . ingenious selection of modern electrical control obtains maximum benefit of rolling mill practice and machine design at Granite City Steel . . . . on an hourly basis, production has tripled and the new rougher keeps the finishing train filled . . . .

with Close Coupled Edger

and pushbuttons. However, the operation is relatively simple and only one operator is required for the actual rolling. The speed and direction of rotation of the horizontal rolls, edger rolls and tables are controlled from a foot-master, while the two screwdown operations and side-guard adjustments are done automatically, merely by pressing a mushroom head pushbutton after each pass. The other switches are used for setup purposes and for temporary manual operation in case of necessity. A second roller is used for setting up new schedules and for relieving his co-worker.

Figure 3 is a simple diagram of the power loop arrangement as ultimately used. The two main mill motors are on a common bus with three of the four generators. Load balance between generators is obtained through cross-connected series fields. Load balance between top and bottom motors is obtained through separate motor field load balance windings, excited from a common load balance exciter, which in turn, is excited from a load balance pilot exciter which responds to the mill motor differential interpole voltage. The edger motor has its own individual generator.

Originally, it was intended to have a common bus for all of these machines, the reason being that the edger motor had a field range of 3 to 1 and the proposed reduction in the main mill was 10 to 25 per cent. Allowing for this reduction, plus roll wear in both sets of rolls, the 3 to 1 speed range of the edger motor was adequate.

However, the original conception was changed and this change occurred after the edger motor had been built, but before the variable voltage control board had been completed. New specifications called for 10 to 50 per cent reductions instead of 10 to 25 per cent. This meant that the speed range of the edger had to be in the neighborhood of 4 to 1.

The best solution for obtaining the necessary drive coordination with originally specified machines was to split the bus as shown in Figure 3 with speed matching obtained through edger droop control and reduced edger generator voltage control.

Automatic preset screwdown control was used on both the main mill and the edger for positioning of screwdowns and sideguides. In addition, this preset screwdown control was used as a means for obtaining edger reduced voltage control. Figure 4 shows the manner in which this was accomplished.

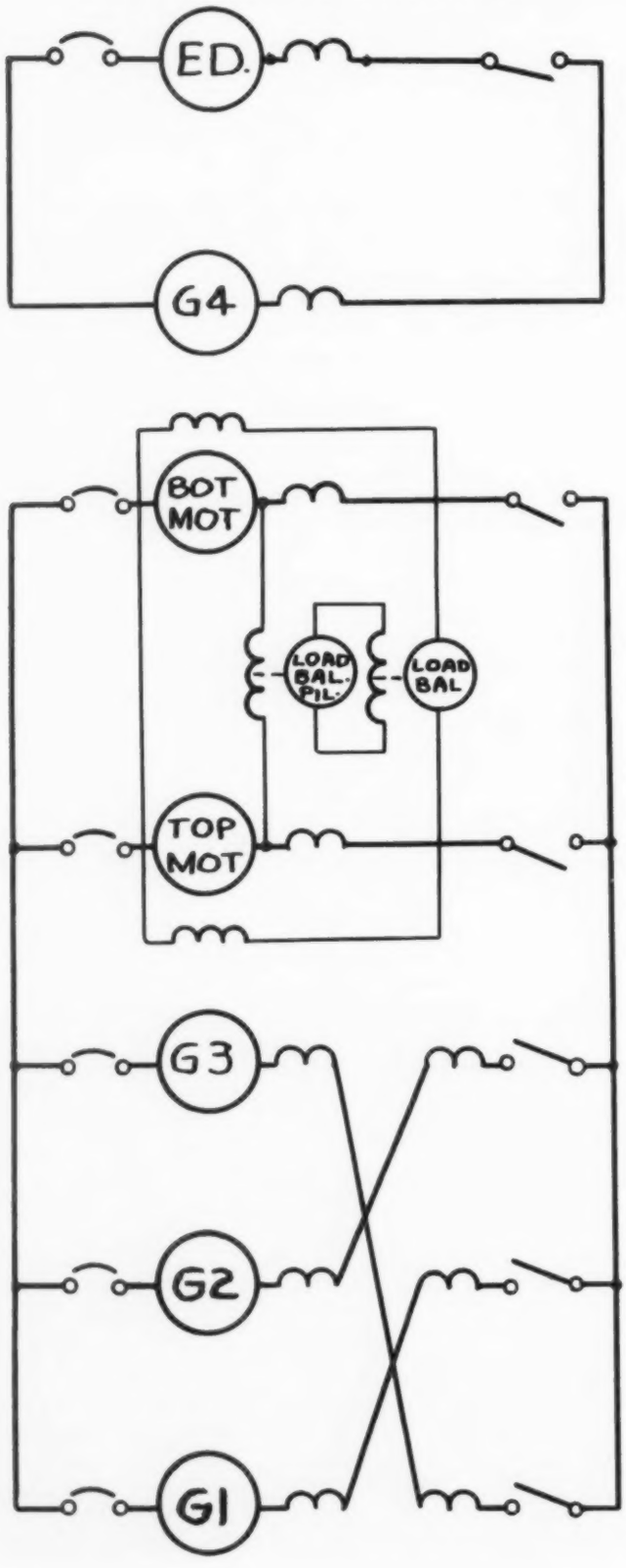
A potentiometer consisting of edger and main roll diameter compensating rheostats, an edger droop exciter, and a reference resistor are connected across the main mill power bus. A potentiometer is also connected across the edger power bus. A rotating amplifier exciter has its control winding connected differentially between the two potentiometers. The rotating amplifier provides the excitation for the edger generator exciter which in turn controls the edger generator voltage by biasing the edger generator field. The edger generator field is in the same excitation loop as that for the main mill generators.

Five voltage relays are connected in one stage of the main mill preset screwdown ratchet relay to permit preset selection of the edger voltage most compatible with the main mill draft to be taken on a particular pass. Thus, the edger voltage can be set and regulated at anyone of five different voltage levels corresponding to five different draft settings which are consecutively 10 per cent apart. The draft range covered by direct voltage control is 10 to 50 per cent. With this arrange-

Figure 2 — Only one operator is needed in the pulpit to operate the roughing mill.

ment, edger motor field can be preset so that, with full load on the mill, the edger no-load speed will be equal to or slightly ahead of the main mill speed. Then by providing additional edger droop, by means which will be described next, speed matching without danger of serious edger overload is obtained over the entire operating range.

Figure 3 — Simple diagram of power loop.



Additional edger droop could be obtained either by biasing the edger generator reference or by providing the edger motor with an interpole excited droop winding. The first scheme, which gives a more responsive system than the second one, was adopted.

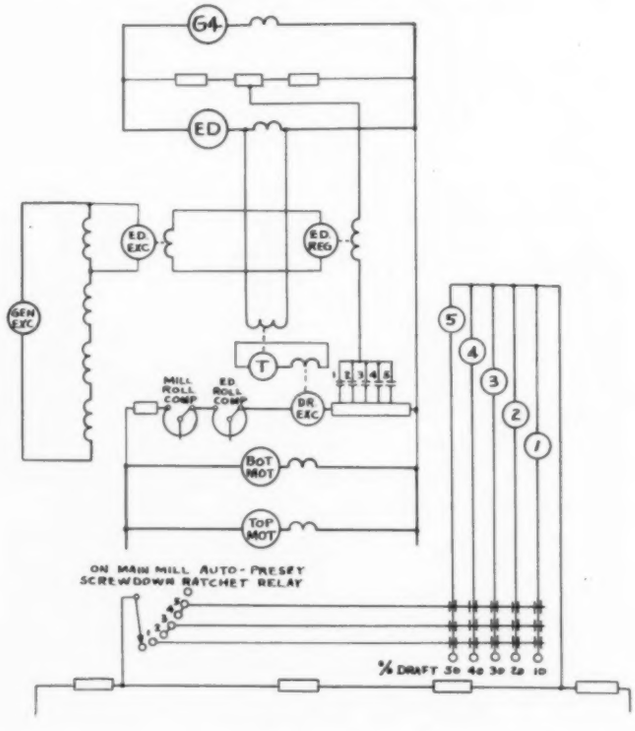
A main mill driven tachometer excited by a signal proportional to edger motor load was used to provide excitation for the edger droop exciter connected in the main mill potentiometer reference circuit. With this arrangement, the edger generator voltage reference is biased proportional to edger motor load. For a given edger load, the biasing effect results in a constant percentage speed difference between the main mill and edger at any draft setting and mill speed.

The utilization of preset main motor field and edger motor field permitted the conventional foot master to be arranged for six steps of voltage control. The arrangement of this control with respect to motor fields, current limit and main mill voltage regulation is shown in Figure 5.

The main mill voltage regulator is of the conventional rotating amplifier type wherein a foot master establishes in six steps a voltage reference across a resistor which is used as one leg of a differential bridge. Another leg of the bridge is a resistor across which a voltage proportional to main generator voltage is developed. The differential leg of the bridge is the rotating amplifier control field. The net rotating amplifier excitation is sufficient to maintain the generator voltage called for by foot master position, and any deviation from this value results in corrective action.

Mill acceleration rate is under current limit control. The rotating amplifier has a current limit winding excited by the differential voltage between the mill motor interpole and a current limit reference signal obtained from a current limit reference source.

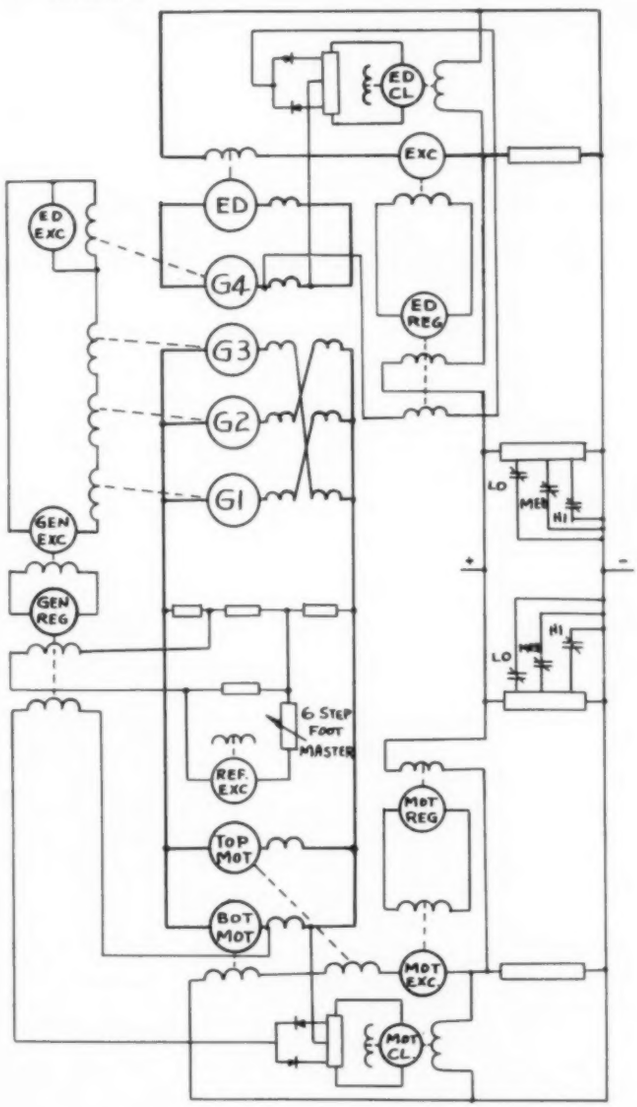
Figure 4 — Preset screwdown control was used as a means to obtain edger reduced voltage control.



The current limit reference source is biased proportional to main motor field strength so that at full field, current limit is effective at 200 per cent full load and at weak field is effective at 175 per cent full load.

The edger voltage regulator is also a rotating amplifier as previously indicated, and causes the edger voltage to closely follow the main mill voltage during acceleration or deceleration. A current limit winding is provided on the edger motor field rotating amplifier to increase edger motor field current, if accelerating peaks greater than 200 per cent at full field and 175 per cent at weak field are obtained. Current limit acting on edger motor field as above, is made ineffective when decelerating to prevent excessive regenerative currents. In addition, edger operation on even passes where no edging is done, is at 375 volts. Main mill motor field excitation and edger motor field excitation are obtained from exciters which are each controlled by separate rotating amplifiers. By means of three pushbuttons, "Lo," "Med," and "Hi," the reference voltage for these amplifiers is simultaneously selected and compared to a voltage proportional to the respective motor field current. The net voltage difference excites a control winding on the respective rotating amplifier resulting in a net rotating amplifier output sufficient to maintain the respective field currents called for by the pushbutton selectors. Any deviation of either main motor field or edger motor field from the selected value results in corrective action by the field regulator involved.

Figure 5 — Schematic shows field control and current limit switches.



A typical five pass schedule load chart is shown in Figure 6. The table in the lower right hand corner lists the operating conditions existing during the test.

Figure 7 shows the no load reversal characteristics of the mill for each of the preset motor fields namely low, medium and high. Based on a recording chart speed of six inches per minute, average on load reversal times for these field settings are respectively 2.6, 2.7 and 3.1 sec. It is seen that this mill easily meets the modern reversing mill requirement of 4.0 sec reversal from top speed forward to top speed reverse. Accelerating current peaks at weak field operation are approximately 85 per cent.

A detailed description of the preset screwdown control for positioning of screwdowns and side guides is given in a paper by A. W. Schlechte and C. Allan Schurr, "Preset Screwdown Control of Reversing Rougher at Granite City Steel Co.," May 1957 *Iron and Steel Engineer*. A summarization of the general features may be of interest at this time.

Automatic operation of the horizontal roll screwdown, vertical roll screwdown and front and back side guides was considered indispensable for thickness and width control as well as for relieving the operator from a myriad of duties.

The horizontal roll screwdown is powered by two 75-hp, compound-wound motors running at 515 rpm with gearing to provide a top roll travel speed of 34.3 in. per min. Increment settings, through a main and vernier slider unit on the schedule selector panels in the operator's pulpit can be set as low as 0.025 in.

The vertical roll or edger screwdown is powered by a 50-hp compound-wound motor running at 550 rpm with gearing to provide a travel speed of 132 in. per min total change of roll opening. Increment settings, through main and vernier units, can be set as low as $\frac{1}{8}$ in.

The side guides are driven by four 10-hp, compound-wound motors running at 800 rpm and are adjusted for a normal movement of 2 in. each, thereby giving a total change between guides of 4 in. Normal operation of the side guides is automatically controlled from the stepping relay associated with the vertical edger roll position controller. For odd-numbered passes, the front guides move in for proper rolling position and the back guides move out for clearance; for even-numbered passes, the back guides move in and the front guides move out for clearance.

The schedule selector panels, of which there are two, are mounted near the operator so that he may select the proper schedule and change schedules to suit rolling requirements. By having duplicate panels, a new schedule may be set up while the previous one is in use. Pistol grip switches are used to transfer control from one preset schedule to the other. The panels are suitable for 15 passes although normally only five passes are made.

The work tables and feed rolls adjacent to the mill as well as the slab delivery and mill runout tables are

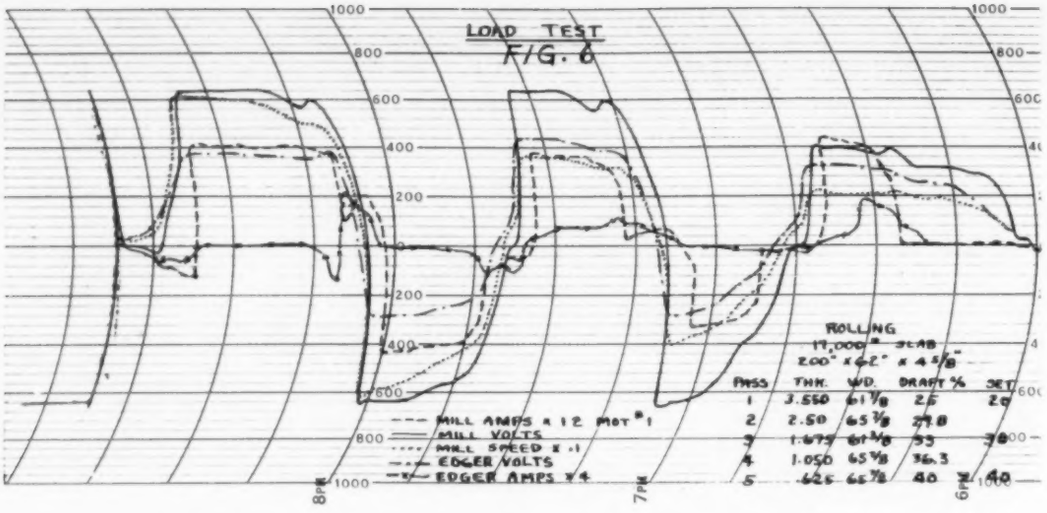

LOAD TEST
FIG. 6
ROLLING
11,000 # SLAB
200" x 42" x 4 5/8"
PASS THK. WD. DRAFT % SET
1 3.550 61 1/8 2.5 20
2 2.50 65 3/8 29.8
3 1.675 67 1/8 33 30
4 1.050 65 3/8 36.3
5 .625 65 7/8 40 40
MILL AMPS x 12 MOT #1
MILL VOLTS
MILL SPEED x .1
EDGER VOLTS
EDGER AMPS x 4

Figure 6 — Test curves on typical five-pass schedule load chart.

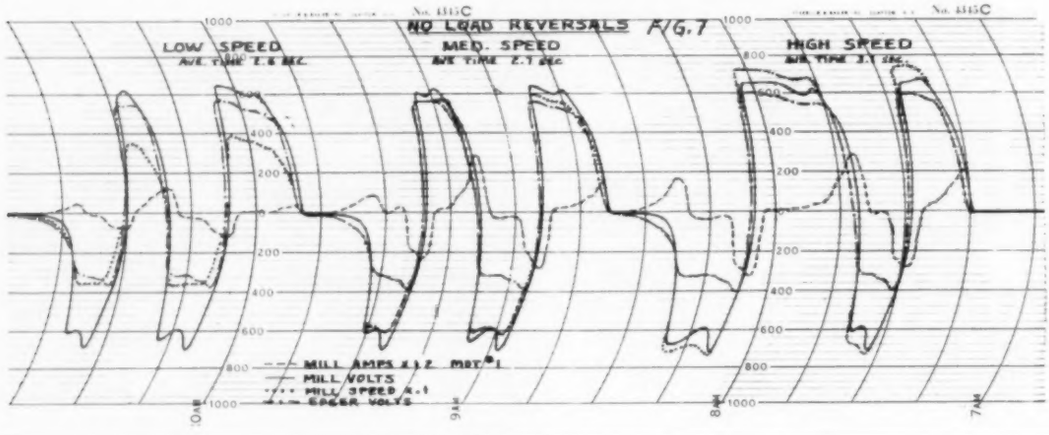


Figure 7 — Test curves give no load reversal characteristics on a mill for each of three preset motor fields.

operated by variable voltage equipment. Directional and speed variation are obtained by tying the table control in with the six point foot master switch. Since the main mill motor fields are preset, all mill and table speeds are proportional to the amount of foot master displacement.

SUMMARY

The reversing mill application presented here demonstrates the versatility of modern electrical control in compromising machine design and rolling mill practice to provide for a satisfactory and acceptable drive. This may not be the ultimate in speed matching between main and edger rolls, but it does represent a solution that worked out quite satisfactory. Production, on an hourly basis, has tripled and there is no difficulty in keeping the finishing train filled.

This new mill receives slabs up to $7\frac{1}{4}$ in. in thickness and reduces them in five passes with the result that the entering temperature at the finishing mill is higher and more uniform. Also, because of the preset screwdown control, better uniformity is obtained on width and thickness. If any deviation occurs because of "puffing up" of the rolls, it is a simple matter to readjust the venier setting.

The rolling schedules on this mill change quite frequently and the initial setting of the four sideguides, which must be done manually by the operator, becomes a minor nuisance. For any future mill of this kind, it may be wise to consider preset control for this operation also.

DISCUSSION

PRESENTED BY

J. H. HOPPER, Systems Application Engineering Section, Steel Mill Engineering, General Electric Co., Schenectady, N. Y.

J. H. GREINER, Application Engineer, Electrical Application Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

J. H. Hopper: The authors of this paper are to be congratulated for the very complete and thorough description of a number of rather ingenious things that they have done on this mill. I want to ask a few questions which are not entirely clear to me from the presentation of the paper.

1. Does the automatic screwdown equipment or the equipment associated with it also automatically select the draft compensation for the edger speed?

2. I notice that the main generators have a load division scheme that is quite common in the industry. I would like to ask if the authors know of any good way in which this scheme can be used, if it is desirable or necessary to operate the mill with one generator out. That is, on an emergency basis, with one generator out, is there any reasonably easy means of operating this mill?

3. I notice the buttons for selecting the motor field weakening. Is this motor field weakening operation performed during the reversal or before the reversal, or

does the operator press the button after he gets the motor up to full voltage?

4. From a quick inspection of the diagram, it appears that the only feature for limiting current on the main drive operates on generator voltage rather than on the motor field. Offhand it appears that this would tend somewhat to limit the performance of the drive, in that the motor operating with weakened field would be at reduced torque. A current limit circuit which would strengthen the motor field before it started to reduce generator voltage would seem to give more assurance against possible stalling of the drive.

J. H. Greiner: Your questions will be answered in the same order in which they were asked.

1. The draft compensation for each pass is set up on the selector board in the same manner that the screwdown operations are set up. After that, the draft compensation selection is also automatic.

2. If one generator is taken out of service, it is necessary to insert a jumper between the differential field bus and cummulative field bus of the machine removed from service. If the circuit breaker and knife switch for the unused machine are open, operation can continue, but the unused machine will be "hot" unless the two series fields have their external connections broken.

3. The motor field strength can be selected at any time because the circuit is only partially set up and will not be completed until the preset screwdown button is operated at the end of each pass. So in effect, the motor field weakening (or strengthening) is done at the end of each pass before reversal occurs.

4. Your statement about reduced torque is correct. However, it must be remembered that the original conception changed after considerable equipment had been built and this is a compromise scheme. If we attempted to strengthen the motor field, our speed relationship between edger and main motor would be upset. Actually the loss of torque does not present any problem in mill operation because the operators use full field on the first pass, medium field strength on the next two and weak field on the last two passes.

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MODERNIZATION

By
F. R. PULLEN
Fuel Engineer
Bethlehem Steel Co.
Johnstown, Pa.

▲ IN a large integrated organization such as Bethlehem Steel Company, careful control of the uniformity and the quality of product is maintained through every process from mining of the ore to the final finishing operation.

Open hearth steel from selected heats is used in the manufacture of forged and rolled circular forgings. Every heat is handled with care during the refining process, with special attention to slag and temperature control and other metallurigcal factors involved in the production of high-grade steels.

Steel is poured into large ingots which are first broken down on a bloomer and then rolled into rounds on a billet mill. After prolonged controlled cooling to prevent injurious stresses, the blooms are transferred to the wheel plant storage area. Here the blooms are sawed or sliced cold and fractured into blocks of predetermined weight, ranging from 50 to 2000 lb, depending upon the size and type required for the section which is to be rolled. Strict weight requirements are imposed in either case to insure the required uniformity in size of the finished shapes.

At this point, a careful inspection is made of both ends of the steel blocks. Blocks showing any internal defects are immediately rejected while blocks with minor surface defects are reconditioned by scarfing or chipping. Those that have passed weight and surface inspections are then ready for charging into the heating furnace. Here they are slowly brought to rolling temperature and soaked for a prescribed length of time, depending upon their size.

The wheel division of the Johnstown plant built during the first World War consists of two mills. No. 1 mill, known as the "slick mill" after its designer, combines a forging and rolling operation to produce, in a single operation, small industrial type wheels, gear blanks, turbine rotors, and other similar circular products. The No. 2 mill, of which the principle product is railroad wheels, was originally installed in 1907 at Midvale Steel and Ordnance Company in the Nicetown plant of Philadelphia. With erection of the wheel mill at Johnstown, this mill was moved from Nicetown in 1917, and produced its first wheel in 1918.

Since there was practically no other alternative, all of the heating furnaces installed with the mill originally were batch-type, reversing, regenerative furnaces. The burners utilized were of the crudest type, and control of the combustion process was entirely in the hands of the heater.

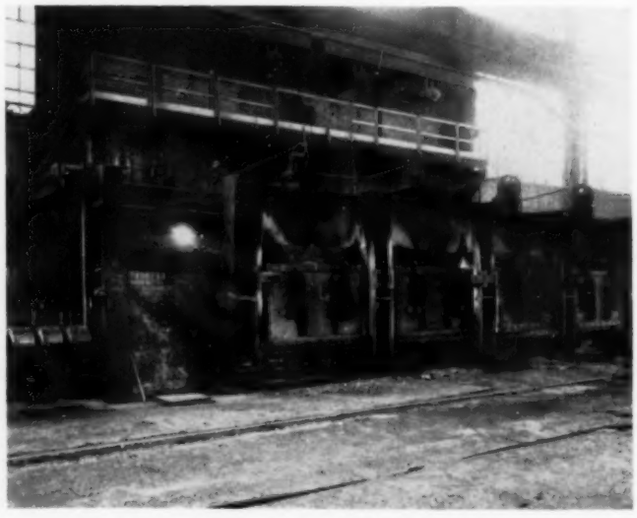
These furnaces, properly operated, produced the wheels and outer circular forgings that established Bethlehem's reputation as a manufacturer of high quality circular products.

Since the construction of the wheel plant at Johnstown, the pace of our daily life has increased many times. The railroads progressed to the operation of long trains at sustained high speeds, compared with the slower and much shorter trains of the past. This imposed much greater braking loads on the wheels. As a result, metallurgical requirements of wheels produced today are extremely severe when compared with former standards. Highly technical metallurgical testing procedures replaced the crude methods of the past. Design of furnaces and related combustion equipment have developed from a "rule-of-thumb" basis to an engineering science. Automatic control of furnace temperature, fuel-air ratio controls, and the like, which are now common practice, were unheard of at that time.

In order to maintain position as a manufacturer of high quality forgings, it became necessary to make a detailed study of the entire wheel-making operation. In general, the results of the study indicated that heating was our most serious problem.

The quality of the heating at No. 1 and 2 mills was such that a high rejection rate was experienced. Major reasons for the high rejection rate were: (1) the blocks were subjected to thermal shock when charged into a hot furnace; (2) some blocks were not thoroughly soaked out in the heating operation, thus creating a potential source for laps in the rolled product; and (3) lack of furnace temperature, fuel-air ratio and furnace pressure controls caused decarburization of some blocks to such an extent that the finished product failed to meet specifications. The study also indicated that

Figure 1 — Old furnace at No. 1 mill was a batch type regenerator unit.



OF WHEEL HEATING FACILITIES— Johnstown Plant, Bethlehem Steel Co.

. . . . reconstruction of heating furnaces for wheel mills at Bethlehem's Johnstown plant has eliminated a previous bottleneck, given improved finished product and reduced heating as well as maintenance costs . . . .

there was not enough reserve heating capacity to sustain an uninterrupted rolling schedule when rolling heavy blocks.

The furnace at No. 1 mill was a batch-type, regenerative furnace similar to that shown on Figure 1.

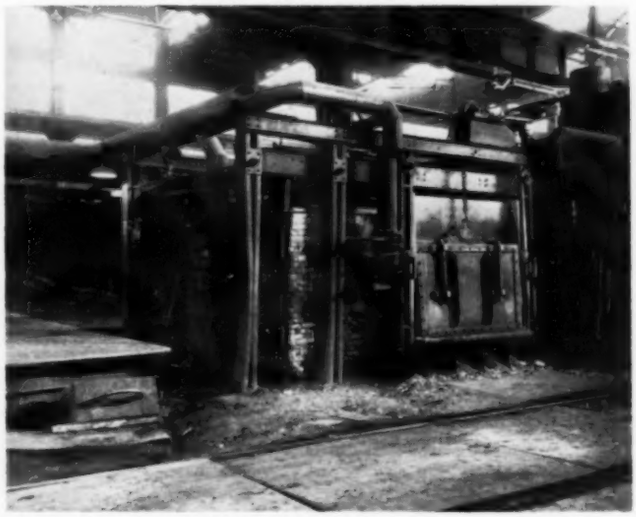
At No. 2 mill, heating of the blocks for the first forging operation was performed in either a sloping-hearth, continuous furnace, or a batch-type, regenerative furnace (Figure 2).

The initial reheating for the second forging operation was accomplished in one of two batch-type furnaces. See Figure 3

The final reheating of the forged blank prior to rolling was accomplished in a furnace similar to that used ahead of the second forging operation. This furnace was similar to that shown in Figure 1.

Since the modernization of the heating facilities at No. 2 wheel mill presented a greater problem than that of No. 1 wheel mill, that portion of the program will be discussed in greater detail.

Figure 2 — At No. 2 mill, blocks for first forging operation were heated in a sloping hearth continuous furnace or batch type regenerator furnace.



DESCRIPTION OF MILL OPERATION

No. 2 wheel mill consists of the following units: one rolling mill, two charging machines, five presses, one rotary heating furnace and two rotary reheating furnaces.

The initial heating of blocks is carried out in a 55-ft rotary-hearth furnace. The blocks are mechanically conveyed and handled from the final block inspection station to the charger which picks them from the charging conveyor and positions them inside the furnace. Blocks are automatically positioned on the hearth in double or triple rows as the length permits. The time required to reach final temperature of 2250 F is about 3 hr. A similar machine picks the heated blocks, in proper sequence, from the furnace and places them on the discharge conveyor. From this point, they travel through the descaler and into the die loader which positions the blocks in the bottom die of the first forging operation.

The resultant wheel blank is transferred from the press to the rotary hearth reheating furnace by a charging machine. It is reheated to approximately 2250 F, requiring about 20 minutes to complete the heating cycle. The blank is then removed, descaled and placed in the die at the second forging press (12,000 ton) by the charger.

After the second forging operation, the blank is placed in a die at the hub punch press (750 ton) where a hole ranging from $2\frac{1}{2}$ in. minimum to $7\frac{1}{4}$ in. maximum is punched through the hub.

The punched forging is transferred to second rotary hearth reheating furnace where it is reheated to

Figure 3 — Initial reheating for second forging operation was done in one of two batch-type furnaces.

about 2150 F, in approximately 20 min.

The rolling mill consists of six rolls: one tread roll, two web rolls, two edging rolls and one guide roll. A 900-hp motor drives the web rolls which shape the web and rim bores of the wheel. All other rolls are friction driven. The tread roll forms the contour of tread and flange, the edging rolls roll the rim faces, and the guide roll helps steady the wheel in the mill. This rolling operation increases the wheel diameter about 3½ in.

The rolled wheel is then stamped in a stamping press (320 ton) as required by the Association of American Railroads.

The wheel is transferred to the coning press (2600 ton), which rounds up the wheel and positions the hub in relation to the back rim face.

Wheels are then placed on rails where they cool to approximately 1000 F before they are transferred to slow-cooling pits. When they have cooled to room temperature, the wheels are removed to beds for inspection and then sent to the finishing shop for machining or to the heat treating plant for treatment.

This mill produces an average of approximately 13,500 one-wear wheels, 6000 multiple-wear wheels, and 2500 miscellaneous forgings per month when working 18 turns per week, for a total of 6500 net tons per month. The blocks rolled on this mill range in size from 8-in. rounds weighing 120 lb a piece to 15-in. rounds weighing 1900 lb.

Products are: forged steel wheels for steam, diesel and electric railway service, mine-car wheels and miscellaneous forgings such as crane-track wheels, gear blanks, brake wheels and bowl shells.

The installation of the new furnaces and the auxiliary equipment with a minimum of interference with mill operations presented the problem of scheduling construction to fit in with mill schedules. The mill was operating on a continuous 15 or 18-turn schedule. The entire area was crowded, leaving little room for storage of construction material at the site.

In order to minimize travel time from the furnace to the next operation, it was necessary to locate the new furnace at least partly in the area occupied by the furnaces presently in operation.

Scale-sized cut-outs of the new equipment were positioned on scale drawings of the area. After several arrangements were studied in detail, the final location for each piece of equipment was determined and detailed engineering could then begin.

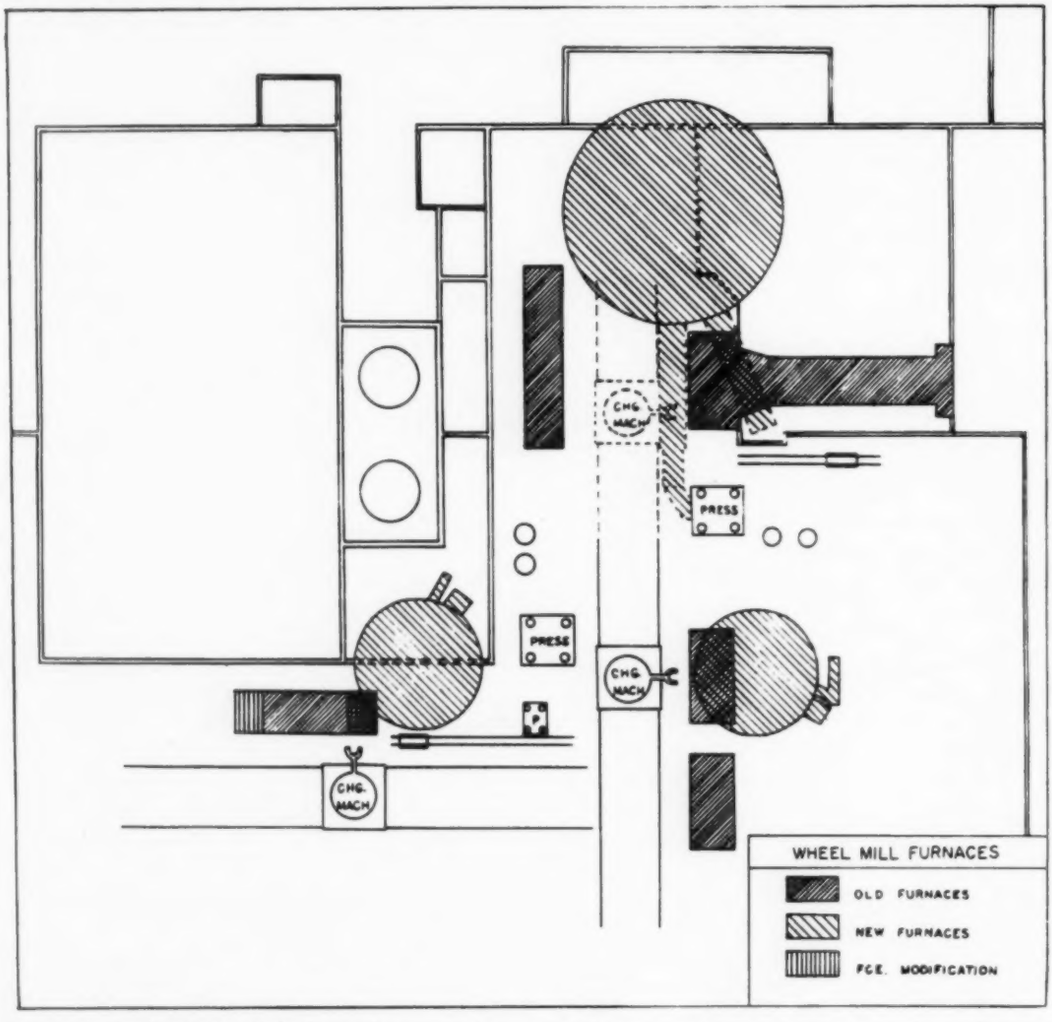


Figure 4 — Schematic sketch shows mill and furnace arrangement before and after construction program.

Further review of the operations indicated that the furnaces should be built in reverse order; i.e., the final reheat furnace should be built first and the initial heating furnace should complete the program. By such a schedule, loss of mill product would be held to a minimum.

The two reheating furnaces at No. 2 mill and the No. 1 mill heating furnace, were originally installed at the Johnstown shell plant and had been dismantled and stored when this plant was abandoned at the close of the Second World War.

Figure 5 — Rotary furnace, for which form work is shown, will replace heating furnace shown at the right.

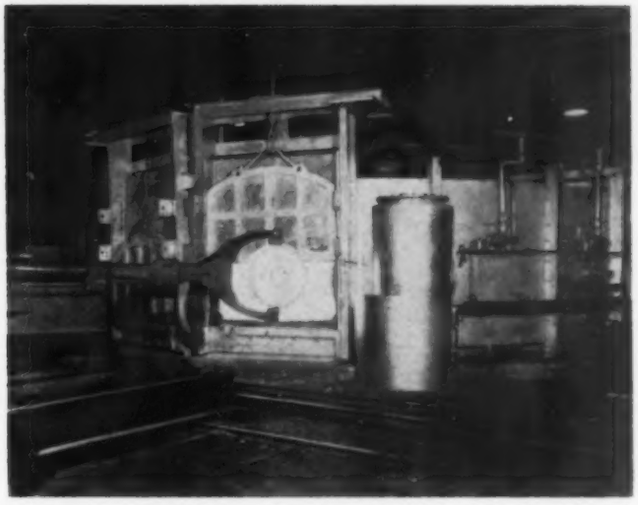


Figure 6 — Rough-forged wheel blank is being charged into new rotary furnace.

The furnaces were reconstructed according to the drawings furnished at the time of their original installation with the exception that the sand seals around the inside hearth rings were replaced with water seals. Combustion control equipment was modernized and combination gas and oil burners were installed.

Figure 4 shows the mill and furnace arrangement prior to the beginning of the construction program and following its completion.

The interferences, other than those normally associated with construction, were not severe in the case of the second reheat furnace. The flue from the furnace and one end of the furnace had to be removed. The furnace was operated without a stack during the construction period. A building wall had to be relocated and a temporary location had to be found for the electrical and combustion control panels. A crane runway support column posed a problem until it was decided to position the furnace in such a manner that the column was in the hub of the furnace in a position where it did not interfere with the hearth drive.

Figure 5 shows the construction of the formwork for the furnace foundation. The furnace at the right is the heating furnace to be replaced by the rotary furnace. In the background is the mill that rolls the finished wheel.

Figure 6 shows the completed furnace with a rough-forged wheel blank being charged.

The first reheating furnace presented a much greater problem to both the construction and operating department. One of the two batch-type reheating furnaces had to be removed before construction could be started on the new furnace. This would reduce the rolling rate on heavy wheel sections. By rearranging production schedules as much as possible, so that a predominance of lighter sections could be rolled while the furnace capacity was limited, and by staggering operating schedules to give extended mill downtime over to the construction crews, the furnace was completed with practically no loss in production.

Construction of the new 55-ft hearth diameter rotary furnace for the initial heating operation remained to complete the program. The site of the new furnace must be convenient to both the existing stock yard and the first forging press. It had to be so located that practically all of the furnace construction could be completed before it was necessary to shut the mill down for the final phase of its construction.

By extending the mill building about 20 ft in length, it was possible to build the entire furnace without interfering with the two existing furnaces. Late in the furnace construction it became necessary to remove about one-third of the batch furnaces in order to provide for the flue to the stack.

With the furnace essentially complete, it was necessary to shut the mill down to remove the existing furnaces, prepare the site and install the charging and discharging machines and the associated conveyors. This was originally scheduled for about a two-week period. However, at the time of the shutdown, orders had fallen off to such a degree that it was not deemed necessary to work to such a close schedule. Consequently, the mill was shut down on May 15 and resumed operations on June 25. The new furnace was lighted on June 17, allowing eight days to dry it out and bring it up to temperature.

Figures 7, 8, 9, and 10 show various phases of construction of the new furnace.

NO. 2 MILL—ROTARY HEATING FURNACE

Description of heating furnace.—This furnace is a five-zone, 55-ft, outside diameter x 31-ft inside diameter rotary heating furnace. The average fuel rate is 4,150,000 Btu per ton, including fuel consumed in the reheating furnaces. The average production rate is 13 tons per hour.

Furnace burner arrangement—There are 41 natural gas and oil burners of the temper flame type distributed as given in Table I.

TABLE I

Zone	Outside ring	Inside ring	Maximum Btu per hr release
1	0	0	
2	5	3	12,576,000
3	10	6	41,920,000
4	8	4	31,440,000
5	3	2	7,860,000
	26	15	93,796,000

Figure 7 — View shows initial phase of construction of 55-ft hearth diameter rotary furnace for the initial heating operation.

Figure 8 — Opposite side of furnace shown in Figure 7 at a time slightly later in the construction program.

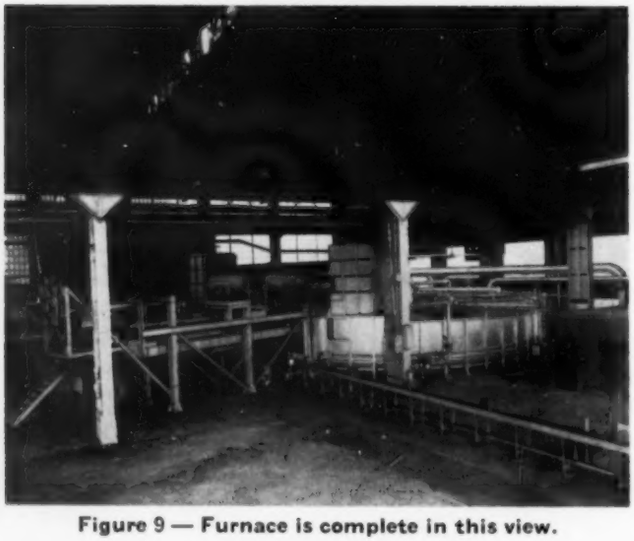


Figure 9 — Furnace is complete in this view.

Combustion air—The combustion air is furnished to each of four fired zones by individual turbo compressors:

The air is not preheated and flue gases are drawn off by natural draft through a stack. Combustion air flow is indicated by air-flow, and fuel-flow gage for each zone.

Figure 10 — Blank is being charged into new furnace.

The furnace operates on either natural gas or Bunker "C" fuel oil, with gas being the primary fuel. Fuel flow for each zone is indicated with total furnace fuel being recorded.

Furnace temperature—Temperatures in zones 2,3,4, and 5 are individually controlled, recorded and indicated. The temperature in the first zone is not recorded.

The temperature controller in each zone receives an electrical impulse from a radiation pyrometer sighted on the closed end of a ceramic tube, inserted in the furnace wall. The control instrument then actuates a fuel control valve as the need for more or less fuel arises. Automatic reset and proportional band control is applied on each zone. Fuel-air ratio in each zone is automatically maintained by a ratio controller.

Furnace pressure—The furnace pressure is measured in the roof and is recorded and automatically controlled by a regulator which positions a damper at the base of the stack, For most operations, the furnace is held at 0.05 in positive pressure measured at roof level.

Safety equipment—This furnace is equipped with the following safety features:

Each of the four combustion air fans is installed with a pressure control on their respective air lines. All of these are wired in series with a regulator on the gas line. Failure of any of the above will close the safety shutoff valves on the fuel lines. The safety shut-off valves must be manually reset by the furnace operator before he can relight the furnace.

The radiation control eyes are also wired in series with a relay switch which, in the event that an "eye" fails due to overheating, will actuate the control motor on the zone, causing it to close and thus shutting off the fuel to the zone.

The furnace has water seals on the inner and outer rings, with an automatic water-level control on each seal. When the level in the seal drops below a certain point, it trips a magnetically controlled valve that opens and permits water to flow into the seal until it reaches the desired level. A continuous flow of water would have been more desirable. However, the only source of water, in the quantity required for the seals, was not suitable for such an application.

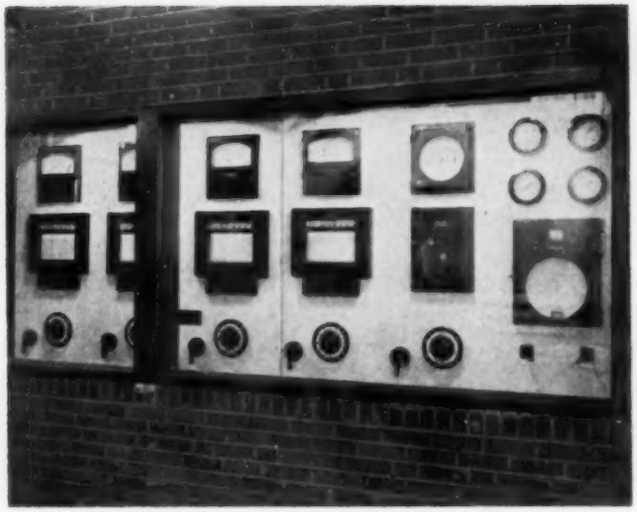


Figure 11 — All control instruments used by heater are mounted on this control panel.

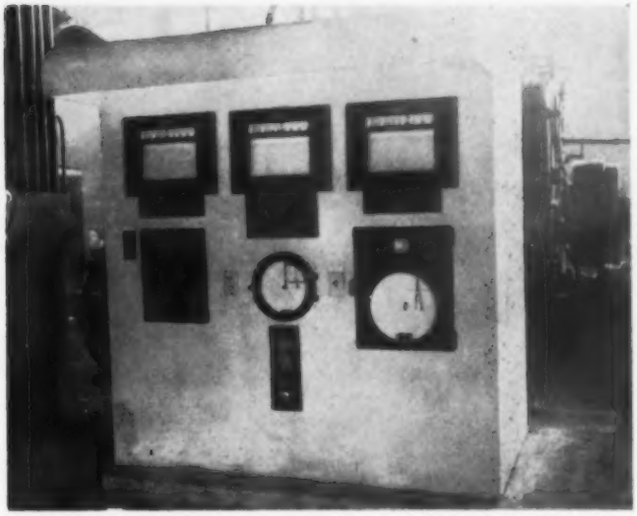


Figure 12 — Control panel for one of the reheating furnaces.

Figure 11 shows the furnace control panel on which all of the control instruments used by the heater are mounted.

The reheating furnaces, and the No. 1 mill furnace are duplicate furnaces to all intents and purposes. They are doughnut-type furnaces with an inside hearth diameter of 16 ft-8 in. and an outside diameter of 29 ft-4 in. The hearth width is 6 ft-3 in. Each reheat furnace is a four-zone furnace; No. 1 mill is four-zoned, fired with either natural gas or fuel oil through proportioning-type burners. Air for combustion is supplied from a turbo compressor type blower at 24 oz. Furnace temperature is automatically controlled in each zone by means of thermocouples in closed-end tubes mounted in the furnace side walls. Fuel flow is recorded and totalized and furnace draft is automatically controlled by positioning the damper provided in the outlet flue.

Figure 12 shows the furnace control for one of the reheating furnaces.

Since all of the new furnaces have been in operation for slightly over two years, the results of our program can be summarized in the following statements:

1. The previous production bottleneck that was caused by lack of heating capacity has been eliminated.
2. Quality of the finished product has been improved by proper control of the heating cycle.
3. The ability to control the furnace atmosphere in the new furnaces has minimized the decarburization of the wheel block.
4. The heating cost has been reduced due to higher operating rates, improved yield and the substitution of natural gas for fuel oil previously used.
5. The labor cost of the heating section has been reduced.
6. The furnace maintenance cost has been reduced.

AISE ANNUAL CONVENTION

GOLDEN 50 YEARS ANNIVERSARY

September, 23, 24, 25, 26, 1957

Penn-Sheraton Hotel

Pittsburgh, Pa.

Measurements for the Consistency of Lubricating Grease

By

BEN HOLLIDAY, Chemist, Material Handling Dept., Crucible Steel Co. of America, Midland, Pa.

▲ SINCE as early as 1400 B.C., greases of one type or another have been manufactured. These early greases were combinations of beef tallow and lime, which formed a sticky, slightly greasy compound. After Drakes' first well in 1859, is found the first record of petroleum lubricating grease as known today. Very little progress was made, until recently, concerning the scientific testing and composition of lubricating greases. This was due, in part, to the type of machinery and dispensing equipment available. The early machines were low speed, and grease was placed where needed with a paddle. As the design of newer equipment required better methods of application, the grease cup, the pressure grease gun and finally the centralized grease system appeared. With these newer and more efficient methods of application, a more scientific approach to testing and understanding lubricating grease developed.

The term consistency, as applied to a lubricating grease, refers to the flow-pressure characteristics of a grease, or simply to the hardness or softness of a grease. This term has been applied too loosely, and does not take into consideration other factors such as soap structure and texture. Consistency has been accepted as the most important physical property of a lubricating grease. The measurement of consistency has had a long interesting history. In the early days of grease making, a measurement of consistency was made by the simple expedient of pushing the finger into a sample of grease, and this was compared to the last batch. This method was highly subjective, crude and incapable of recording; some type of mechanical finger had to be devised. In some measurements the grease sample was removed from the kettle and chilled in ice water, then the penetration noted. Some grease makers using this chilling method admitted this did not give a true picture of the grease structure or texture but was a convenient test method. All consistency measurement instruments are essentially indentation devised and differ mainly in the size and shape of the plunger.

Best known and most widely used is the double-pitch cone of the ASTM and IP standard. Under a total load of 150 grams, which includes both the cup and shaft, the instrument has a useful range of 3.9 cm of 390 units of penetration. The grease sample is placed in a grease cup, the cup is jarred to drive out trapped air and cooled to 77 F in a bath. After sufficient cooling, the grease extending above the rim is removed with a spatula. The grease cup is placed under the penetration cone and adjusted so that the tip of the cone just touches the surface of the grease. The cone and shaft are allowed to fall free for five seconds and the penetration is then noted. Three or more tests are made on the same cup, the average of the values is reported as the penetration. The unworked penetration of a grease is not a reliable measure of its consistency, since the grease may change in transferring or other handling before the penetration is taken. If unworked penetration is required, it may be determined in the sample container as received. The worked penetration, which is the basis of the present NLGI classification, is performed in the same manner except after cooling to 77 F, the grease is subjected to 60 full double strokes in the grease worker. The cup is jarred to remove trapped air, the surface is leveled, and worked penetration reported as the average of three or more determinations. This ASTM grease worker consists of a metal plate $\frac{3}{16}$ in. thick with 51 $\frac{1}{4}$-in. diam holes arranged in three circles. The plate is 2 $\frac{15}{16}$ in. diam while the inside of the grease cup is 3 in. The plate travels a distance of approximately three in. per stroke of six in. during a full double stroke. The capacity of this grease worker is approximately 300 cc or 10 ounces.

For determination of block grease penetration, the grease, which must hold its shape, is cut into a 2-in. cube, chilled to 77 F, and penetrations made on three faces of the grease cube. The average is reported as the block penetration.

The Karns-Maag instrument is so constructed that by pressing a trigger a set of jaws open and permit a ball of definite weight and diameter to fall a specified distance into the center of a standard cylinder containing the grease to be tested. The depth the ball

. . . . the NLGI has set up a grease specification which will be of help to the lubrication engineer . . . . each classification covers a range of 30 points and each range is separated from the next by 15 points . . . . consistency, however, is primarily a means of estimating the ability of a grease to be applied to a bearing . . . . other tests help determine usefulness of grease . . . .

penetrates into the grease is measured. For greases too hard to be determined in this manner, the ball falls on a pin which is held by a disk above the grease. Due to the fact that it offers no outstanding advantage over the ASTM procedure, and that no factor exists for conversion to the equivalent ASTM consistencies, it has lost favor.

The Abraham Consistometer consists of a spike-shaped plunger which is forced through the sample of lubrican at a uniform velocity. The force required to cause penetration is applied by means of a hand-wheel and screw, the force being transmitted by a spiral spring. The elongation of this spring is indicated by a pointer on a scale which is graduated in metric units. The plunger penetrates at a rate of 1 cm per minute. Plungers having areas of 0.01, 0.1, 1.0 and 10.0 sq cm are used, depending upon the type of grease. Results are reported as the cube root of the pressure and are known as Abraham hardness numbers. The instrument, however, is very expensive and requires careful manipulation to obtain accurate results.

The Sinclair-Knoff instrument is similar to the Abraham consistometer. It consists of a spike-head plunger which penetrates the grease. Actually the grease sample is raised on a platform by means of a constant speed motor at the rate of 8.9 in. per min against the fixed plunger.

Another type of penetration device is the Gardner mobilometer. It consists of a brass tube in which the grease is placed. A circular line indicates the height to which the tube is filled. A plunger, of standardized dimension and weight, carries a disk at its lower end and a scale pan at its upper end. The time required for the plunger to descend through the grease is noted. Three standard disks are used; No. 1 is solid, No. 2 has three small holes, and No. 3 has four large holes. A wide range of greases can be tested by employing different disks and adding different weight to the scale pan.

Torsion type instruments, which consist of a plunger or paddle suspended by a torsion wire being rotated in the sample, have been used on the semi-fluid greases. Two instruments of this type are the MacMichael and the Stromer viscosity tester. These have proven of little value in the testing of greases.

The lack of any commercially accepted standards for the various consistencies of greases resulted in considerable confusion and misunderstanding in the past. To correct this situation, a National Lubricating Grease Institute classification of greases based on the ASTM worked penetration, was set up and adopted in 1941. It should be pointed out that the classification in no manner indicates quality or performance.

The grease classification is:

NLGI	*ASTM Worked Penetration*
No. 0	355–385
No. 1	310–340
No. 2	265–295
No. 3	220–250
No. 4	175–205
No. 5	130–160
No. 6	85–115

It should be noted that a gap in consistency exists between each grade; consequently, there is no overlapping of grades, and also no possibility of one grade being substituted for another.

Modifications and adaptations of the standard ASTM penetration test have been developed and are being widely used today. The use of the motormatic or mechanical grease work has been incorporated into the Federal specifications for testing lubricants under Method 313.1. The grease worker conforms to the standard worker except that the plunger plate has 270 holes, $\frac{1}{16}$ in. diam, the standard hand worker having 51 holes $\frac{1}{4}$ in. diam. The grease is packed into the worker and the mechanical worker performs as many strokes as required. The Federal Method 313.1 requires 100,000 double strokes (about 28 hr) for completion, the grease is then cooled to 77 F and the penetration determined. A test to determine the shear stability of a grease is based on the mechanical grease worker. The purpose of this test is to note the relative increase or decrease in consistency after a grease has been worked for a specified number of strokes. The sample is worked in the hand worker for 60 strokes, its penetration noted, then placed in the mechanical worker for 10,000 strokes, after which its penetration is again noted. It has been fairly well established that the greatest change in consistency comes during the first 10,000 strokes, after this the change is very slight. The soap type structure has the greatest influence on this increase or decrease in consistency.

The ASTM has a proposed method for the cone penetration of greases using a quarter-scale cone and worker. The method is applicable to greases ranging from NLGI No. 0 through No. 4, and contains procedure for both worked and un-worked penetration. The quarter-scale method is not intended to replace the full scale penetration, but was developed for use where only small samples of grease are available. The primary use of this quarter-scale cone is for the determination of consistency of a grease sample after use, such as a sample of grease taken from an electric motor bearing. The quarter-scale value is converted to the full scale penetration by the following formula:

Full scale penetration =

3.75 (quarter-scale) + 24 penetration

The quarter-scale worker plate has eight holes of $\frac{1}{8}$-in. diam and has a capacity of approximately 4.5 cc or 0.17 ounce.

The Shell Micro cone penetration was developed to measure consistency of a grease that had been worked in the Shell Roller Test. The Shell Roller Test is a measure of mechanical stability of a grease. It simulates conditions encountered by roller bearing greases in actual operation. In this test, the grease is first worked for 60 strokes in a standard worker, then transferred to the micro container and the micro penetration is established at 77 F. The grease in the container plus additional amount from the grease worker, to make approximately 100 grams, is transferred to the hollow cylinder of the roller tester. The weighted solid roller is inserted and the assembly is locked in position. The cylinder is eight in. long and four in. in diameter; the roller is seven in. long and $2\frac{3}{8}$ in. diam, weighing 11 lb. The whole assembly is rotated, the roller revolves along the inside cylinder wall, kneading the grease. The test is four hours in length at 160 rpm. After the test, the micro penetration is determined and the per cent change noted. The Shell Micro Cone is a true cone, whereas the ASTM cone is a double cone. The total weight of the Shell Micro cone and shaft is 58.3 grams, and the test cup holds 75 cc or about 3 ounces. There is an average relationship between the Shell Micro cone penetration and the ASTM method, the lower the NLGI grade the closer the relationship. Above, say grade No. 4, the lighter Shell cone is not reliable.

Another modification of the standard penetration now under study by the ASTM is the Universal Penetrometer Cone. The Universal cone used with the ASTM penetrometer is a single means of testing a grease from block grease to oils of about 180 SSU at 210 F. The weight and size of the Universal cone is identical to the standard cone, except the Universal cone is solid, thus preventing oil from spilling inside the hollow cone and increasing the weight. The results are identical between the Universal and standard cone for all greases from No. 6 to No. 0. To determine the penetration of heavy oils, the scale must be altered to permit a free drop of at least 620 units of penetration. The Universal cone is now in the process of cooperative testing by the ASTM.

For determining the consistency of semi-fluid greases, a tapered-hole penetrometer disk has been developed. This disk is so constructed that it is used with the standard ASTM penetrometer, has a total moving weight of 150 grams, and displaces 2.34 cu in. of grease as compared with 2.27 cu in. displaced by the ASTM cone at full penetration. The disk is $2\frac{3}{4}$ in. diam, $\frac{1}{2}$ in. thick and has 12 tapered holes, 0.585 in. on bottom to 0.281 in. on top. The disk is allowed to fall free for five seconds, the penetration then noted. This tapered-hole disk has the advantage over the light weight cone in that it does not float in very soft grease, whereas the light cone is insensitive and sometimes floats.

In respect to determining the consistency of a lubricating grease, it has been stated that we need a method for determining consistency at more than one temperature. Using 77 F as a basis, grease could be better evaluated, at say 27 F, 127 F and possibly 177 F. A temperature of 77 F can be considered as the normal room temperature at which a grease is stored, but in actual service, 127 F is more likely to be encountered in industrial applications. Since a grease contains approximately 80 per cent petroleum oil and oils show a decided difference in fluidity with temperature change, it may be possible to establish a viscosity index system for lubricating greases.

It has been shown that a great deal of work has been done to develop new and better methods of determining consistency. It is very likely that better methods than we have now, will be developed. It is fitting that now we should examine some factors that have a very definite bearing on the consistency and texture of a lubricating grease.

Additives—A variety of compounds or materials are added to lubricating greases, generally in small concentrations, to improve specific properties of the finished product. Of the long list of additives for greases, perhaps the three most important are oxidation inhibitors, rust inhibitors and extreme pressure agents. Oxidation inhibitors when added to most greases, in small amounts, usually produce no change in consistency. An exception to this is in the case of certain antioxidants added to soda base grease. Phenol type additives lengthen the fiber of soda grease, resorcinol shortens the fiber, and hydroquinone will destroy the fiber structure. Corrosion and rust inhibitors show different response depending upon the type of lubricating grease to which they are added. These inhibitors, for the most part, have no bearing upon the consistency of a grease. The addition of extreme pressure agents to grease sometimes produces changes in texture and consistency since a lead soap is used in the formulation of steel mill grease. The lead soap itself is a thickening agent in this case. Another fact is that different type soap thickness requires varying amount of an extreme pressure agent to obtain the 35 lb Timken OK Load required. Additives have a much greater effect on the inorganic base greases, since the gelling properties of such grease depend upon the attractive forces between the particles of the thickener. If an additive attaches itself to the surface of the gell particle, the internal force between the particles is changed, thus altering the physical properties of the grease. For the most part the additives have little effect upon grease consistency, and the effects, if any, are corrected by the manufacturer.

Final water content—All systems of soaps and hydrocarbons are changed in texture, consistency, and other characteristics by the addition of certain substances such as water, fatty acids, alcohols, glycerols, etc. These compounds, polar agents, tend to lessen the extreme insolubility of the soap to combine with it, facilitate crystallization. The influence of these compounds will vary for every particle soap base, from being detrimental to being advantageous. In the case of aluminum soap products, water will decrease the gell strength of the soap or in some cases completely destroy it. This is due to the hydrolysis of the soap. The addition of alcohols or other polar agents to aluminum base greases will tend to soften the product and

make it more fluid. Water is employed as a stabilizer in almost all calcium greases. The electron microscope has been used to study the effect of water on the fiber structure of calcium grease. With 1.3 per cent water the fibers were twisted, forming a firm structure. When partially dehydrated to 1.1 per cent water, the fibers started to untwist. At about 0.7 per cent water, only a trace of fiber remained, and when dehydrated to 0.4 per cent water, all fiber structure disappeared. Therefore in calcium base greases, the water content has a direct bearing on consistency, 1.5 per cent water gives a soft grease of about 320 penetration, 2.0 per cent water a medium grade of about 280 penetration, and 2.5 per cent water a hard grease of 230 penetration. The figures are only averages and may vary. In the sodium base lubricating greases, water has a lesser effect, varying from about 0.3 per cent for a No. 0 to about 1.0 per cent for No. 6. The sodium base brick and block greases are usually boiled until practically no water remains. The water content of barium base greases is not as critical as in the case of the other type lubricating greases. About 0.1 per cent of water is desirable, but up to 0.5 per cent may be used for certain types. Lead base greases are not too dependent upon water content, but about 0.5 per cent water is added as a stabilizer. Lithium base greases require a small amount of water as a stabilizer, but water has little effect upon the finished grease. The consistency of the inorganic base greases is extremely sensitive to small amounts of water. The water undoubtedly absorbs on uncovered spots on the gell particle surface, increasing the interparticle force; thus the more water present, up to about 1.5 per cent, the less the penetration and harder the grease. Since water has an effect on all greases, the irreversible consistency changes which sometimes occur after having been stored for some time at elevated temperatures, appear to be connected with a loss of moisture.

Fillers and bodying agents—Fillers will be considered as solid materials which add bulk, and if present in sufficient amount, decrease the penetration of a lubricating grease. Most fillers are added to greases after the soap fibers have formed and consequently should not interfere with structure formation. A great variety of solids of various types are added as fillers, some of these materials act as solid lubricants. Graphite will, when added as a filler, change the consistency of grease depending upon the amount added. The addition of 3 per cent or less of graphite has little influence upon consistency. As the proportion of the filler is increased, it appears to have some thickening effect. For example, a cup of grease of 325 worked penetration before addition of 10 per cent graphite, has a worked penetration of 295 after the addition. Products consisting of 15 per cent calcium soap, 45 per cent graphite and 40 per cent 100-sec at 100 F oil have worked penetration of about 100 to 135. To obtain similar consistency without the filler would require at least 30 per cent calcium soap. Mica in flake form is sometimes used as a filler in lubricating greases. An average mixture of grease and mica contains from a fraction of a per cent to 5 per cent mica, acting much as graphite. The use of asbestos as a filler in greases was more prevalent in the past than it is today. Asbestos, added to a grease, shows a marked thickening effect. For a general statement we can say each 5 per cent of added asbestos will lower the penetration 25 points. The slippery nature of talc or soapstone, has made it attractive as a filler in some lubricants. The addition of talc in amounts of 3 per cent or over will lower the penetration in proportion to the amount added. A great many other materials such as clays, metal powders, yarn, hair and cork have been used as fillers for greases. This practice of adding fillers is almost a thing of the past.

Manufacture—Certain steps in the manufacture such as cooling rate and milling have an effect upon the consistency of a grease. Sodium base greases consist of fibers which immobilize fluid lubricants, these fibers vary greatly in size from a long fiber through medium to a short or even non-fiber texture. The temperature of filling soda base greases will influence the length of the fiber. When products are agitated as they are cooled, the fiber is pulled out and becomes longer. If the product is filled at a higher temperature, a shorter fiber results. For short or non-fibrous greases the product is cooled as rapidly as possible without stirring. If the processing temperature is increased, the grease will have a heavier consistency. The higher temperature may be responsible for more complete saponification, a lower water content, a lower glycerol content, or better dispersion of the soap.

The softer grades of sodium greases, No. 1 and No. 2 are normally made by adding oil while agitating a previously cooled heavier grade, therefore they tend to exhibit long fibers. In aluminum soap greases, it is customary to hold the charge at a temperature of 275 to 300 F for one to two hours, since this treatment produces a more stable grease with a heavier consistency due to stronger gell formation. Too rapid cooling of aluminum grease will cause the product to become lumpy or grainy. The fiber structure of barium base grease changes as the temperature drops, at 300 F the mixture is stringy, at 250 F a flaky mass is obtained, and at 200 F the product is smooth and buttery. Lithium base greases can exist in products of different texture from fiberous to buttery, this texture is dependent upon the cooling rate. In general, slow cooling with or without stirring, results in coarse fibers, while rapid or shock cooling results in fine fibers of soap. In the case of the non-soap silica gell grease, the processing temperature and mixing time will effect the consistency.

For a grease with 7.5 per cent silica, 30 minutes mixing gives a product of 320 worked penetration, 90 minutes mixing gives a 335 penetration. As for processing temperature, with 10 per cent silica, 50 F gives 275 penetration, 100 F gives a penetration of about 325.

The use of milling as a processing step in grease manufacture is becoming increasingly important. The effect of milling upon a finished grease, with respect to penetration, varies depending upon the formulation and processing. Lithium grease is milled to shear the product to a point where little change in consistency will occur in storage or use. Sodium base grease will decrease in penetration upon milling, a 435 penetration will drop to about 350. For the most part greases will decrease in penetration upon milling.

Chemical factors—The structure and consistency of a grease is a function of the chemical nature of the soap.

The difference between various fatty acids chains which form soap structures, has been viewed by the electron microscope. Lithium hydroxy-stearate forms twisted chains, while the normal stearate forms a straight fiber, giving the latter a weaker structure. Different fatty acid soaps also vary in their ability to maintain structures under adverse working conditions or temperatures, those of around fourteen to eighteen carbon atoms per chain being the most stable. The fiber structure of sodium base grease is varied depending upon the fatty acid use. If a fatty acid containing a large proportion of unsaturation is used, very long fiber will result. If a predominately saturated fatty acid is used, a short fiber product will result. The per cent of unsaponified fat present in a grease has a direct effect upon penetration, the higher the unsaponified fat the greater the penetration and lower the NLGI number. The greases formed from less-purified oils tend to be smoother than those formed from more refined ones. This is due to slightly polar impurities present in the less-purified oils. The rate of oxidation of the oil used to manufacture the grease must be taken into consideration if grease is to perform over extended periods of time. If small percentages of oil-oxidation products are formed, the grease structure will tend to break down. Highly stable petroleum oils must be used and these are fortified with anti-oxidant additives. Some other factors can also effect this oxidation rate or chemical instability of a lubricating grease, the grease should be neutral or slightly alkaline, very little glycerol present, and the grease should be free of catalysts, such as iron, copper, tin and lead. The many other chemical factors that can effect the texture and consistency of a grease are unlimited and therefore above the scope of this paper.

Character and percentage of soap—By many the consistency of a grease is considered as a measurement of the per cent soap. For all practical purposes this can be considered true, the higher the soap percentage the less the penetration and in turn the higher the NLGI number. Some examples of this are, assuming the same composition soap and same viscosity oil used for each grease. An aluminum grease of No. 0 grade contains 4 to 7 per cent soap with 350 to 380 worked penetration, No. 4 grade has 15 to 18 per cent soap and 175 to 200 penetration. A calcium grease of No. 0 grade contains 10 per cent soap while a No. 6 grade contains 35 per cent soap. A No. 0 sodium grease contains 4 to 6 per cent soap with 350 to 380 penetration while a No. 6 grease shows a penetration of 85 to 100 with 35 to 40 per cent soap. The same condition is true for the non-soap thickened greases, silica and bentone. The higher the per cent thickener, the less the penetration, and higher the NLGI grade.

The structure or texture of a lubricating grease is one of the primary characteristics that contributes to the ultimate service performance. While the terms buttery, smooth, fiber, and gell grease have been used for a long time, technically, little was known of the basic reason for the difference. During the past few years much work has been done investigating the structure of greases. This work is being done with the use of electron microscope. The result of this work has shown that the texture of a grease is dependent upon the size and the shape of the fiber. At any fixed concentration, the smaller the particles or fibers the more transparent the grease. These fibers form a matrix that forms a reservoir to hold the oil until needed. This can be likened to sponge holding water until the sponge is squeezed forcing the water out. The micron is used as a measurement to classify fiber structure. A micron is 0.001 mm or $\frac{1}{25,400}$ in. Micro-fiber greases are less than one micron in length, these are smooth and buttery in texture. Into the above classification, fall the short fiber lithium, aluminum, silica and bentone greases and certain types of calcium. The medium-fiber greases are composed of fibers up to 100 microns in length, usually single, flat, twisted fibers. These are certain lithium, calcium and sodium greases. The long fiber greases contain bundles of fibers which are more than 100 microns in length. These are the fiber type sodium greases and certain barium greases. The tendency for greases to loose consistency under working is due to the fibers being torn to shreds. In the case of inorganic greases, the small particles of silica or bentone are forced into larger particles and withdrawn from their gell network. Another important consideration is the ability of a grease to recover consistency after working. This is known as thixothropic recovery. While undergoing working, some of the soap fibers are broken into shorter fragments, the bonds holding the fibers in place may also be broken, and the fibers have been orientated as well. The healing of a structure or stiffening of a grease following shear has been explained on the basis that perhaps the soap fibers lying one on another can form rigid bonds, possible crystallization. The recovery can be of a lower consistency, the same level, or a higher consistency depending upon the nature of the soap in the system.

This paper has only slightly touched the factors which effect consistency, many papers have been written dealing with each separate factor.

The grease manufacturers have done very outstanding work testing different compounds and their effect upon grease structure and texture, and undoubtedly they will continue to experiment to give the steel industry even better lubricants.

DISCUSSION

PRESENTED BY

DR. R. K. SMITH, Manager of Research, E. F. Houghton & Co., Philadelphia, Pa.

CHARLES R. SCHMITT, Manager National Lubrication Sales Dept., E. F. Houghton & Co., Philadelphia, Pa.

S. R. FREDLOCK, Lubrication Engineer, Weirton Steel Co., Weirton, W. Va.

Dr. R. K. Smith: Mr. Holliday has admirably discussed numerous methods for measurement of grease consistency. Little can be added to the tenor of his comments but we appreciate an opportunity to amplify on certain statements.

First, "Consistency has been accepted as the most important physical property of a lubricating grease." There is no question of the truth of this statement. Consistency provides a means for estimating the ability

of a grease to be applied to a bearing. Before the advent of modern packings, consistency was necessary to maintain the grease or lubricant in position. It is a crude measure of ease of application through a simple grease gun. Even more important perhaps, as Mr. Holliday points out, it gives the grease maker a means of controlling his cooking operation. Variation in animal or vegetable fats used in making grease bases are so great that grease making was, and in some instances still is, an art—jealously handed down from one artist to another.

We think it of importance to emphasize at this time that consistency is a physical test. It is not a performance test nor has it been meant to be. Two bowls of jello have the same consistency, but they taste different because one is lime and the other is strawberry. A crude parallel can be drawn with greases. A lime soap grease may perfectly satisfy the "taste" of a machine under a given set of conditions. With a change in ambient conditions, however, the same grease may not be at all palatable. The chemical character of a grease is all-important in application. Sometimes this can be foretold—sometimes actual performance tests are required to adequately compare one grease with another. In any event, let us summarize by saying that current lubrication engineering recognizes the importance of physical and chemical quality in greases.

The second point brought out by Mr. Holliday concerns the NLGI (National Lubricating Grease Institute) scale. As he stated, this scale bears no relationship to quality but is a numerical method of classifying hardness or softness of various greases.

The author would like to enter a word of caution regarding this classification.

As the NLGI rating increases, i.e., 0; 1; 2; etc., the grease becomes softer. The penetration value, however, decreases numerically. For example, the No. 0 NLGI grease has a penetration of approximately 360. The No. 5 NLGI grease, very much harder in consistency, has a numerical penetration of only 150 approximately. A moment should be taken to make certain that no confusion exists in this respect.

Charles R. Schmitt: Mr. Holliday's paper covered grease classifications. It might be of interest to simplify these terms so that they could be kept in mind a little better.

It will be noted that there is, in each grease classification range, certain common differences that can be used to advantage: (1) each classification covers a range of 30 points, and (2) each classification range is separated from the next by a gap of exactly 15 points.

Therefore, one has only to memorize one of the classification ranges and, applying these numerical "gaps," all the other grease ranges can be derived.

S. R. Fredlock: The fact that so many different methods has been developed for determining the consistency of a grease indicates the lack of something essential to determine the true flow characteristics of greases.

Of the many factors that govern the consistency that Mr. Holliday has related to us, one stands out as the most important to a lubrication engineer; this is soap structure. The properties of a grease that are affected by its soap structure are pumpability, slumping, bleeding and adhesiveness. These properties the lube engineer comes in contact with daily.

It is evident from the paper that consistency alone will not tell the user the quality of a grease or how well it will perform in the various centralized grease systems. The knowledge Mr. Holliday has passed on to us will help in coping with these problems.

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. . . . refractories are not just part of the furnace—they are the furnace . . . . furnace life is practically dependent on refractory life and furnace efficiency can be improved as refractories are developed to withstand higher temperatures . . . .

SYMPOSIUM ON HIGH TEMPERATURE

OPEN HEARTH FURNACES

By

KEITH D. BARTELS

Superintendent Masonry

United States Steel Corp.,

Fairless Works

Fairless Hills, Pa.

▲ THE ordinary meaning or use of the term refractory is to indicate a ceramic material highly resistant to fusion and suitable for furnace construction or maintenance. This is somewhat misleading because a given material having a high fusion point may be a refractory in one use and a flux in another. To illustrate, the oxides that make up the different types of steel mill refractories—CaO, SiO_2, Al_2O_3, MgO, Cr_2O_3, FeO—also are the major constituents of the fluxes and slags which are used in the same metallurgical processes. The difference lies in the manner and proportion in which they are combined. Heat resistance is the primary requirement for a refractory material as high temperatures are a part of steelmaking. What the industrial world means by a refractory material is one that stays put satisfactorily when used in a particular furnace location.

As aptly stated by Dr. Sosman, refractories are not an accessory to the open hearth furnace; they *are* the furnace to all intents and purposes. A very major portion of the cost in the production of steel is the expenditure for refractory materials, the labor for repairs and lost production time caused by the repairs. Open hearth furnaces are by far the largest consumer of refractories, using more than one-half of the total refractories produced, and probably employ a wider range of refractories than is found in any other high temperature process.

In the furnace above floor level, Figure 1, the type of refractories that are utilized are silica brick, basic brick and special magnesite ramming mixes. In the granular and plastic forms, raw, calcined and clinkered dolomite, magnesite, chrome ore, and plastic chrome ore, are used for maintenance of this section. Below floor level, Figure 2, basic brick, high alumina brick, silica brick, fire clay brick and semi-silica brick are all popularly applied in various locations.

Figure 1 — Silica brick, basic brick and special magnesite ramming mix are used above the floor level in the open hearth.

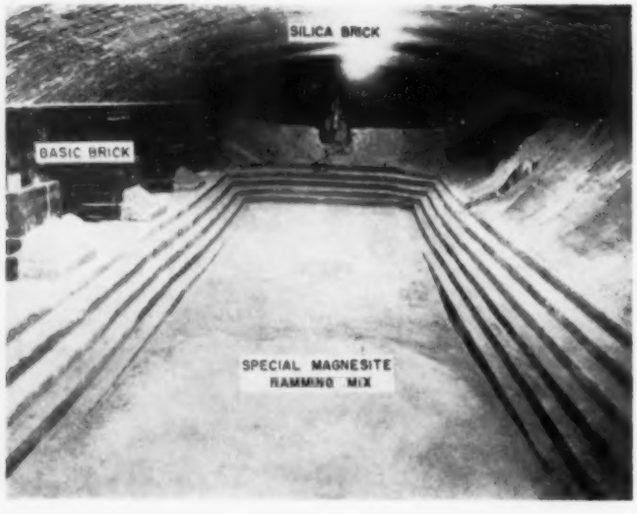
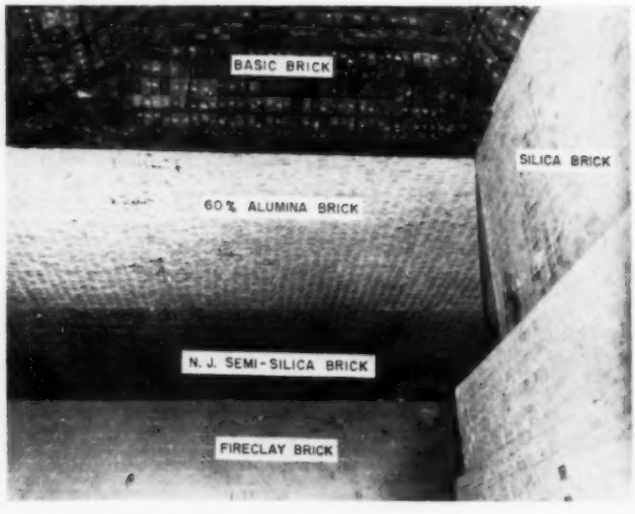


Figure 2 — Fireclay brick, semi-silica brick, silica brick, alumina brick, and basic brick are commonly used below the floor level.



REFRACTORIES

Long furnace life, with a balance of furnace parts, is essential to highest rates of steel production with the lowest repair and maintenance cost on furnaces. Balance of furnace parts implies that the necessity for repairs or reconditioning of a given furnace part should fall due at the same time another section requires repair, or in a multiple thereof. As the main roof requires replacement before other parts of the furnace, port ends, uptakes, slag pockets, checkers and flues should be in need of repairs or reconditioning in multiples of the main roof life and also should bear a similar relationship among themselves. This is an endless problem, and although some degree of perfection is often reached, there still remains a necessity and desire for further improvement. This is a basic challenge to all steel plant refractories people.

Neglecting design and other similar changes, long life and furnace balance are pursued generally in three ways in applying refractories: (1) selection of the best quality of a given type refractory, (2) the use of a higher quality refractory of a different (and usually more expensive) type, and (3) the application of proper wall thicknesses.

Selection through trial and error alone obviously is not desirable, as it is costly in time, labor and material. As service conditions in the furnace vary widely and are indeterminate in relative severity, it is difficult to devise laboratory tests that will indicate the life of a refractory for any specific installation. These tests, however, serve a very useful function in revealing which refractories are most likely to give satisfactory performance. Selection is finally done by calculated trial and error; that is, with physical properties of the materials known, those most likely to perform most satisfactorily are installed, observed in service, and evaluated for over-all cost.

The obvious difference in quality between brands may be seen in Figure 3, which depicts the results of a laboratory test in which various brands of silica brick were heated to temperatures in the open hearth operating range. This difference in quality is often noticeable

Figure 3 — Different brands of brick show wide variations in service.

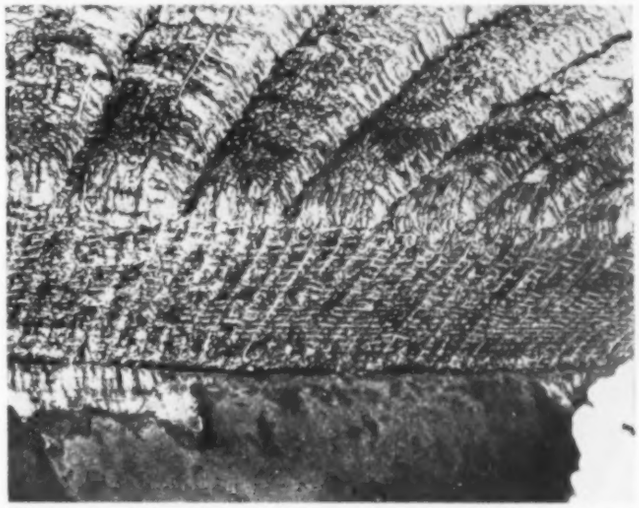


Figure 4 — Operating experience shows better service from brick, in background in this view, which was better quality than that at the top.

Figure 5 — Use of high quality material may have very beneficial results in the open hearth furnace.

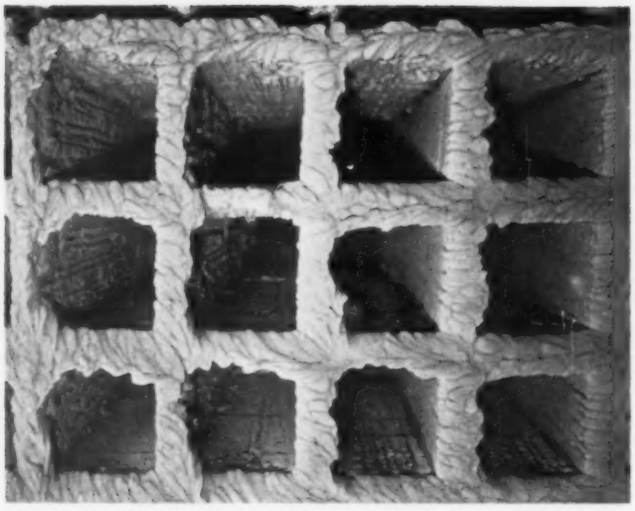


Figure 6 — Better quality brick would have been desirable in this checker installation.

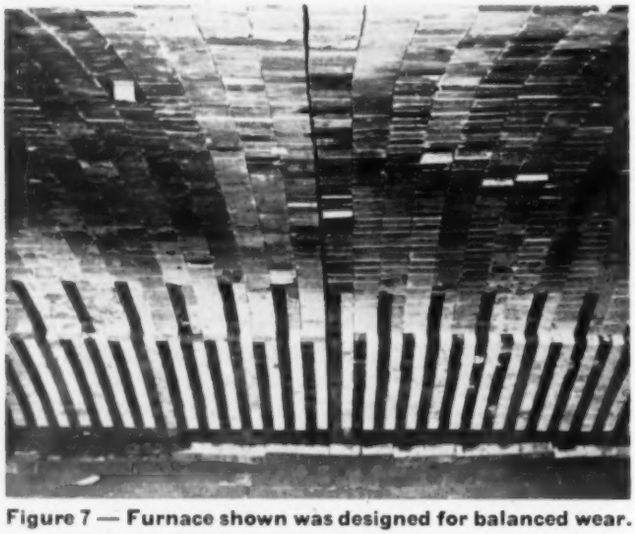


Figure 7 — Furnace shown was designed for balanced wear.

in the field installation. In the upper portion of Figure 4, silica brick of divergent quality were installed in an open hearth furnace roof. The lower quality brick have eroded to a greater extent than the higher quality material.

Figure 5 suggests that benefits can be derived from the judicious use of higher quality material in an open hearth furnace roof, and also reveals the necessity for

Figure 8 — Refractory properties have improved appreciably in the last five years.

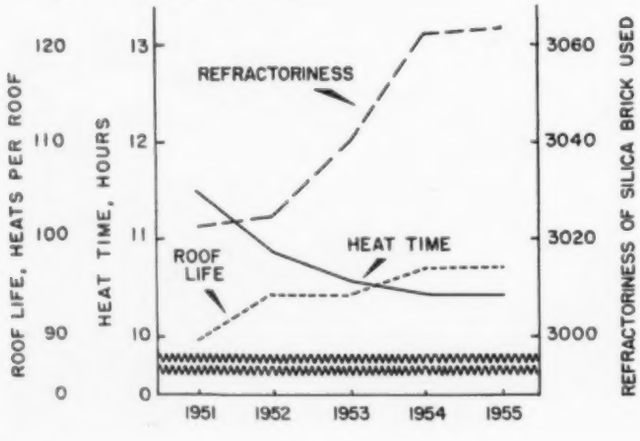


Figure 9 — Excessive heating will adversely affect roof performance.

extending the area in which the "zebra" construction was used. The degree to which basic brick replace silica in port ends is not only a problem of furnace balance but one of over-all economics because of the high cost of basic brick. Figure 6 illustrates the need for higher quality checker brick. High alumina and basic checkers are now in limited use throughout the industry. The results, although optimistic, are not entirely conclusive because insufficient time has elapsed to determine the effect on the over-all cost with the more expensive materials.

In Figure 7, both the thickness of brick work and the use of higher quality refractory have been employed in an open hearth furnace roof to provide a balanced wear pattern in this section.

The co-operative testing and research carried on by the refractories manufacturers and the users of these materials has brought about an over-all improvement in refractory quality to better meet the ever increasing steel production rates. This is particularly true in the case of silica brick as illustrated in Figure 8 by the increase in refractoriness of silica brick with a decrease in heat time, and a gain in furnace roof life over the period of a few years.

All of the problems of furnace life cannot be answered by refractories alone. Care by the furnace operator has a very powerful influence upon the life of refractories. That the purpose of the basic open hearth process is to make steel, not to save brick is obvious. All furnace roofs are operated at temperatures precariously approaching the melting point of the silica roof brick. Prevention of excessive melting of the roof requires a resolution by the operator together with adequate follow-up. Figure 9 clearly demonstrates the results of excessive heating. The lack of care in bringing a rebuilt or repaired furnace up to temperature may cause considerable loss of usable roof thickness by spalling. Tender care after abuse can never repair the damage.

The over-all trend in open hearth refractories is toward increased use of basic refractories. From 1945 to 1950 while ingot production in United States increased 21 per cent, basic brick consumption increased 58 per cent, and silica brick consumption increased 17 per cent. From 1950 to 1955, ingot production increased 20 per

cent, the consumption of basic brick increased 71 per cent, and silica brick only 1 per cent. The ten year period from 1945 to 1955 shows a gain of 46 per cent, in ingot production while the use of basic brick boomed by 171 per cent and silica brick shipments improved by 19 per cent. (These increases are based upon data from United States Government Census of Manufacture reports.) Currently, several open hearth furnaces have been built as all-basic units with suspended basic main roofs and port roofs and basic port ends.

The early development of the open hearth steel making process was retarded by the lack of refractory materials capable of withstanding the high temperatures and the chemical reactions of the process. With few exceptions, none of the present refractories can be said to be securely established in a given application as not only do requirements vary widely with the different practices in different open hearth shops, but changes are constantly being brought about by improvements in refractories and changes in fuels with accompanying changes in design. Even in today's advanced state of development of the open hearth process, it is recognized that additional production and improved steel quality may be possible if new or improved refractories eventually make feasible a sustained operation at higher temperatures.

DISCUSSION

PRESENTED BY

HARRY C. PAXSON, Superintendent—Masonry & Labor, Lukens Steel Co., Coatesville, Pa.

KEITH D. BARTELS, Superintendent—Masonry, United States Steel Corp., Fairless Works, Fairless Hills, Pa.

Harry C. Paxson: The paper said that you had done some experimenting with various wall thicknesses and roof thicknesses, possibly with different types of material. I would like to know whether you would care to tell us what you have found, that is, if you have decided upon any given thickness, regardless of the type of material you are using, for any given furnace.

Keith D. Bartels: In the first place, I would not say that our present practice is necessarily the result of a long period of experimentation. Our open hearth furnaces are slightly over three years old, which is relatively young.

Originally, the roof was 18 in. thick employing superduty quality silica brick at the front and back skew areas with regular quality in the crown. We found our operations to be too severe for that construction, and we are trying to obtain furnace balance with a roof that is entirely super duty silica brick, 18 in. thick at the front and back skew areas with 15 in. brick in the crown. The "zebra" pattern, employing basic brick, is used with the 18-in. brick.

With the exception of the roof, the port ends are built entirely with basic brick. The port endwalls and sidewalls are 13½ in. thick, built at a distance away from the structural binding. The endwalls are 9 in. inside the buckstays and the sidewalls are 4½ in. inside, which permits these walls to be veneered, rather than hot patched, in case they become thin during operations.

REHEAT FURNACES

By

EDWARD E. CALLINAN

Superintendent Masonry and Labor

Alan Wood Steel Co.

Conshohocken, Pa.

▲ THESE remarks on high temperature refractories for reheat furnaces will cover a relatively narrow field, for, beyond the Blooming mill, the 800,000 tons of steel produced annually at the Alan Wood Steel plant are handled by only two furnaces, one a 55-ft diam rotary hearth furnace for reheating slabs for plate mill product, and one 65-ft triple-zone fired recuperative reheat furnace serving the 30-in. strip mill.

Since there is only one furnace for each mill, it is obvious that a furnace shutdown means a mill shutdown. Hence, there is extraordinary importance attached to the refractories used in these units since they can not be allowed to fail during scheduled mill operations. Secondly, since steel production rates and demands currently are so high, only a minimum of shutdown time can be allocated for making scheduled repairs and rebuilds. This, in turn, introduces a third factor of importance to the refractories service life; the rapid and drastic cooling and subsequent heating up rates which must be used so that the personnel can make the necessary repairs in a minimum of downtime. A final factor which also must be recognized is that the two furnaces are pushed to extremes with respect to fuel input rates and temperatures developed to effect the demanded production.

Keeping these introductory points in mind, it will be recognized that our problems may be somewhat dissimilar from those of other plants, and the refractories practices to be mentioned may not be entirely practical or applicable to other shops. Further, it is not claimed that the optimum refractories practices have been attained. We still are feeling our way, and hope to do better as time progresses.

ROTARY HEARTH PLATE MILL FURNACE

Figure 1 is a layout view of this unit. It has a 55 ft outside diameter with a 15-ft. wide hearth. It has four burner zones and one preheat zone, with a total of 40 burners distributed along the inner and outer walls. The flame and products of combustion move counterclockwise and pass up through a vertical flue into a breeching which leads to the stack. As originally installed, the roof and side walls were constructed of No. 28 and No. 26 insulating firebrick.

Figure 2 is an unwound view of the furnace showing certain curtain walls and suspended nosings.

The curtain wall can be used to start the refractories discussion. As originally installed in Sept., 1954, this was a patented suspended design in which spool shaped 50 per cent Al_2O_3 brick were hung together in a link form so as to produce a solid suspended baffle wall to prevent short circuit of the furnace gases from the heating area to the stack.

This baffle wall first fell in on October 4, 1954. Examination of the brick showed vitrification and some slight shrinkage on the hot face side, but, more important, they had developed cracks on the inner shoulder corner and had pulled apart under tension.

Since the original wall had only been butted against the face of the furnace side wall insulating brick, it was felt that if the furnace walls were recessed and the indented face lined with solid, regular firebrick, then when the curtain wall tended to sag or droop, it would push against the solid brick walls so as to arrest the movement and reduce the strain placed on the hanging spool

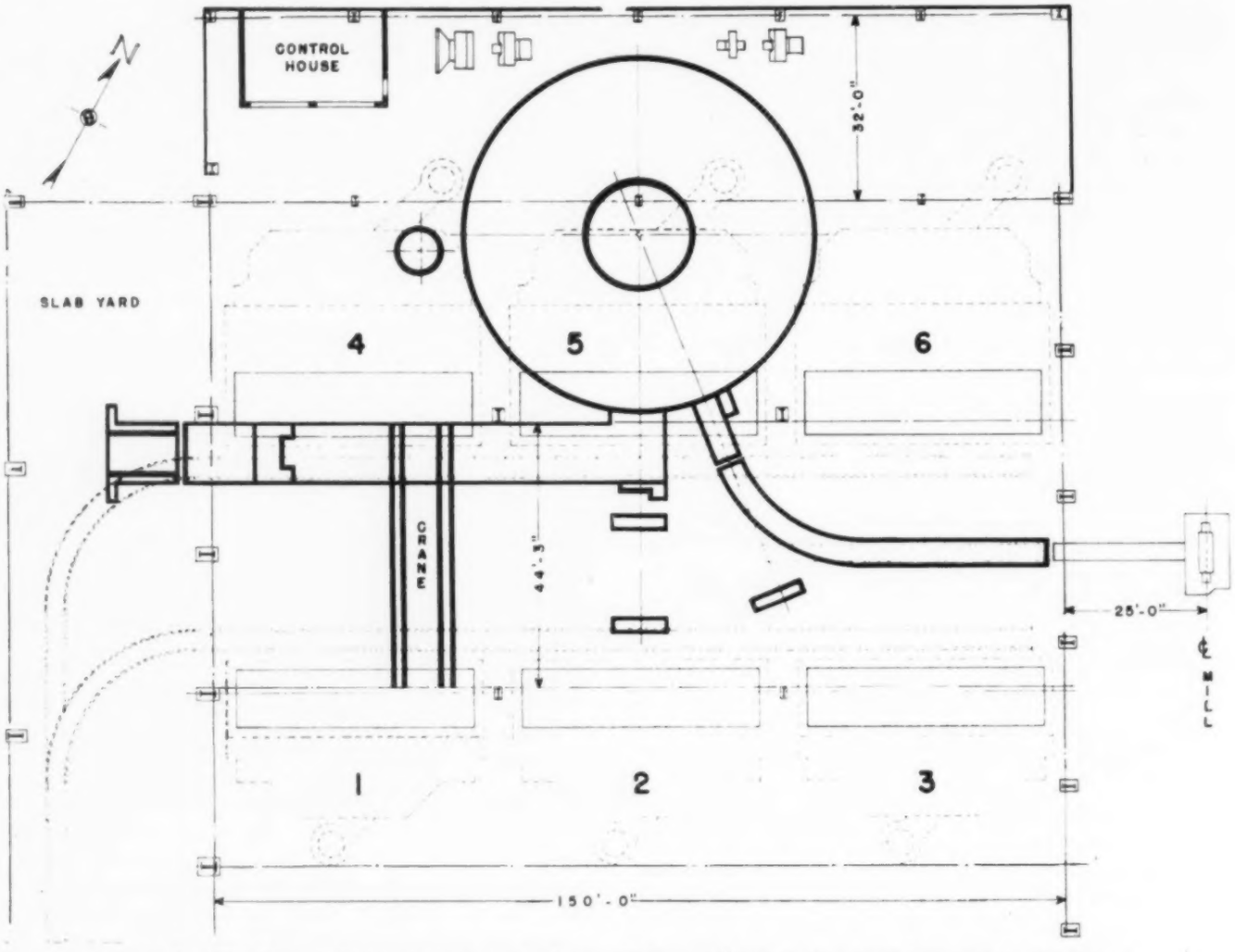
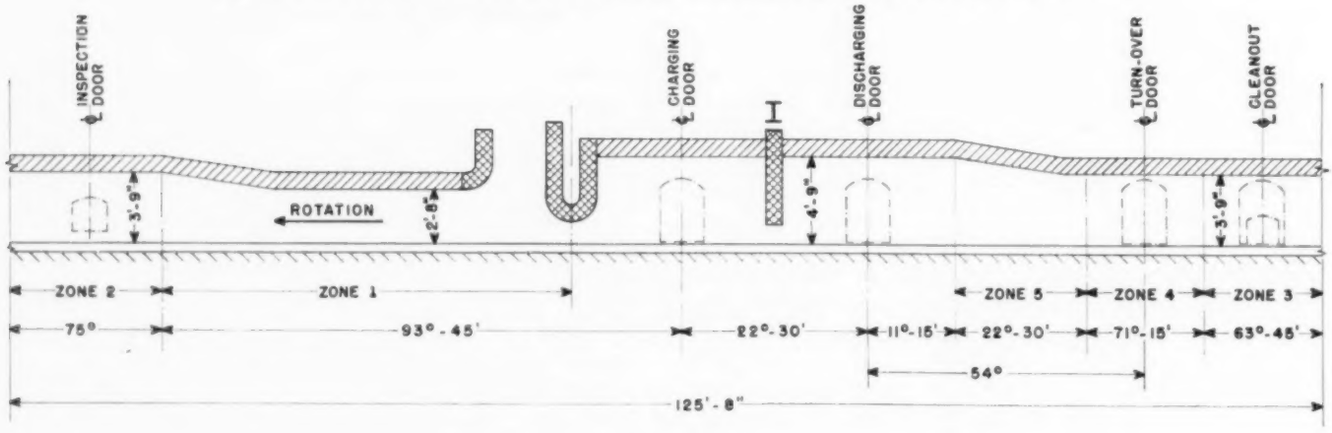


Figure 1 — The layout shows rotary hearth plate mill furnace installation superimposed on old layout.

Figure 2 — Sketch shows an unwound view of the rotary hearth plate mill furnace.



ZONE Nº 1 --- 0 BURNERS
ZONE Nº 2 --- 12 BURNERS
ZONE Nº 3 --- 12 BURNERS
ZONE Nº 4 --- 12 BURNERS
ZONE Nº 5 --- 5 BURNERS

brick. This was installed but fell in on October 12th. It was replaced again with three bottom courses removed to reduce the load. However, it fell in again on October 21st.

It should be mentioned that during this time the fuel rate and temperature of the furnace were being increased as the heating requirements of the furnace product were being learned.

At this time, there were no more brick available for still another replacement, (the success of which would have been very doubtful). Therefore, the following new curtain wall design was evolved and hurriedly installed (Figures 3 and 4). This type wall has been very successful. The original piping still is in use. The rammed material has been patched several times, but its failure has been due to being hit and knocked off by a slab pile-up. The No. 28 insulating firebrick setting on the pipe have been repaired in several sections as they eventually slumped and pulled towards the hot face side. (This really has occurred only on the second and hotter curtain wall which was installed after the first one performed satisfactorily.) Such necessary repairs can be made in a couple of hours time during a weekend shutdown. As mentioned, there are now two walls of this design in the furnace. A second one was placed between the discharge door and the last burner zone so as to

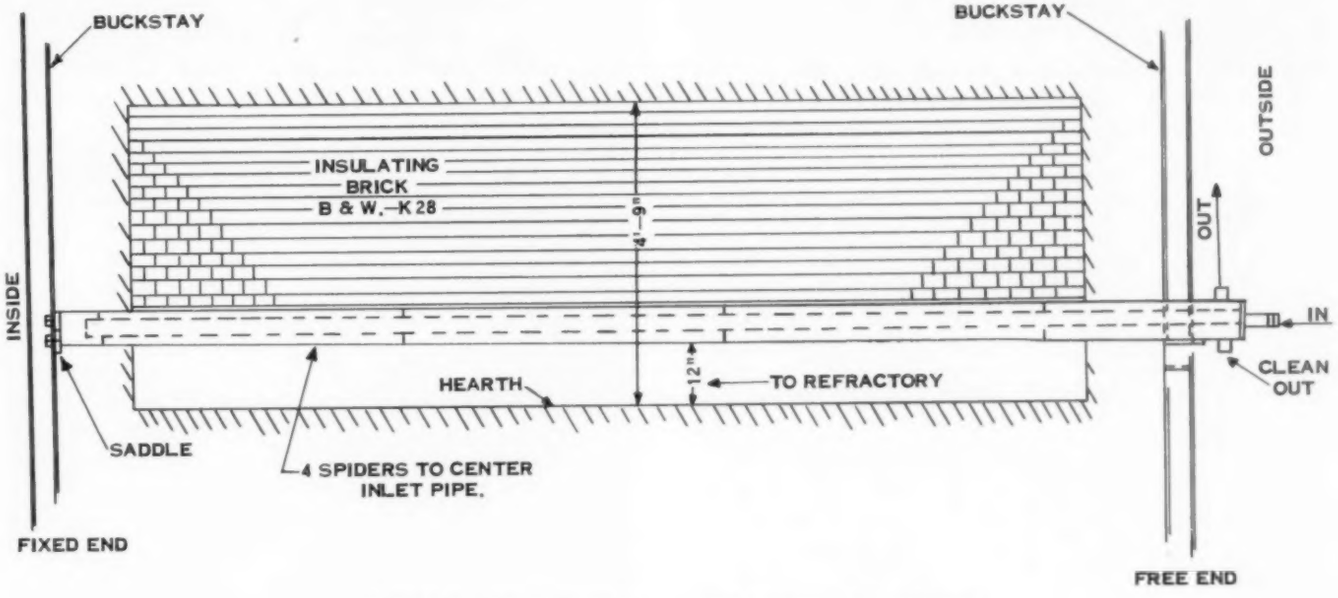


Figure 3 — Curtain wall is carried on water cooled pipe.

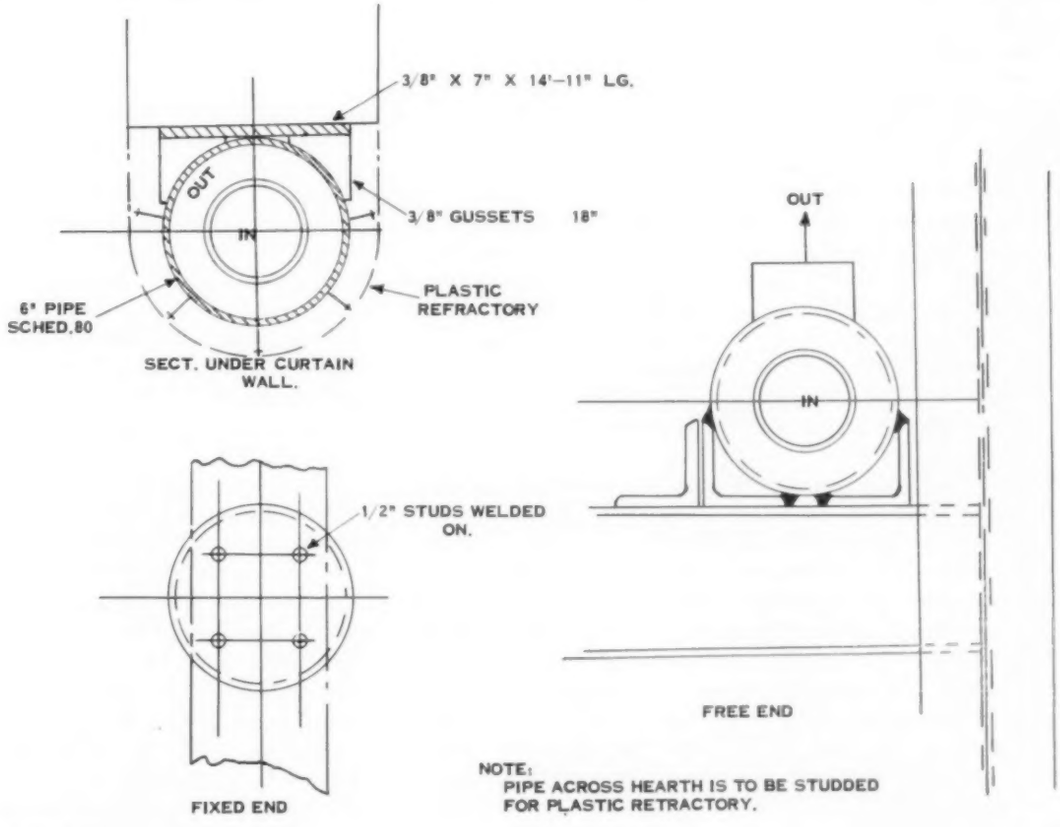


Figure 4 — Details of water cooled pipe which holds curtain wall.

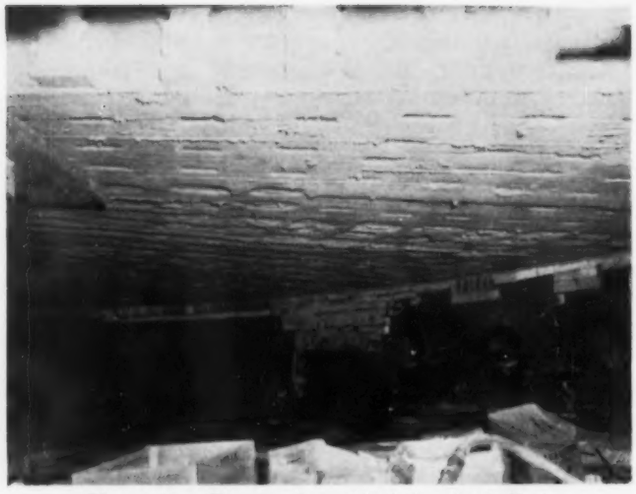


Figure 5 — Rammed roof is being installed.

Figure 6 — Rammed roof is joined to insulating refractory brick roof section.

Figure 7 — View shows design and suspension of insulating refractory roof assemblies.

minimize excessive temperature on the discharge boom. As long as there is no prolonged water pressure failure, we expect these walls to last a long time.

As originally installed, the hearth consisted of a 3-in. deep top layer of super duty clay brick with nine sets of raised ribs 3 in. higher than the bottom proper. Under this top layer of super duty brick is a 3-in. depth of first quality clay castable, then 4½ in. of No. 23 insulating brick and 6 in. of insulating concrete. The raised ribs were made with a special high alumina type brick noted for their resistance to abrasion and slag attack, which had produced proven satisfactory life in rotary furnace bottoms used for heating piercing mill rounds. However, after a few weeks operations, the valleys between these ribs filled up with a hard dense monolithic scale which could not easily be removed. Current practice is to set the slabs on a solid scale hearth which periodically is dug out to the proper working level, and if necessary, further leveled off by the addition of clean mill scale. Consequently, it can be said that there is no true refractories bottom practice required. When this bottom does require a brick relining, a flat layer of hard, high density, low porosity brick, similar to that used for open hearth checkers, should provide satisfactory service life for our type of hearth practice.

As mentioned earlier, the side walls and roof of this furnace originally were constructed of No. 28 insulating firebrick. The roof consisted of presized and cut block units made from ten regular sized brick cemented together and with a cut out in the top so that they threaded on, and were suspended from, an I-beam shaped high duty clay hanger brick. When the furnace was first placed in operation, it appeared for a time that very satisfactory life would be obtained. But, as fuel, temperature, and production rates increased, and as weekend shutdowns with very rapid cooling down and heating up practices were required in order to dress the scale hearth, these roof brick eventually developed a very severe spalling condition. Apparently they absorbed considerable iron oxide which increased their weight in the hot face section, and further produced a vitrified and shrunken layer several inches deep which spalled off, and also produced random direction cracks up through the brick. This condition became so bad that extensive patching was required practically every weekend, and too frequently hot patching was required during operations. It should be mentioned that application of a spray coat of a high temperature cement, said to have the same thermo-physical characteristics as the brick, did not appreciably alleviate this condition.

Based on the very successful life being obtained in our strip mill furnace roof, a 90 degree section of the rotary furnace roof was replaced with a rammed roof construction of super duty class plastic fireclay refractory.

Figure 5 shows this roof being installed. Figure 6 is another view showing the rammed section as it was being completed and about to join the adjacent section of the insulating firebrick roof.

Figure 7 is another view showing the insulating firebrick roof.

Later another 65-degree rammed section was installed, and further installation is planned.

To date, this rammed installation gives every indication of giving long uninterrupted service life. In over eight months time, it has shown only a few spots where a light peeling (about 1 in. depth) has occurred. It is our belief that this peeling is due more to cracking of the corrugated hanger brick, or possibly to improper ramming in spots, than it is to any inherent spalling tendencies of the rammed material. We intend to install other sections of rammed materials in this roof as time permits, until the entire roof is so relined.

The No. 28 insulating firebrick side walls have stood up somewhat better than did the roof. However, they do spall and shell off to the extent that in the 2¼ years of operation, the walls of the entire firing and discharge sections have been more than 100 per cent replaced. Currently, we are making wall repairs with No. 30 insulating fire brick. To date, rammed side walls have not been tried because this would more than double their weight and the binding steel work is considered too light to carry this added load without being reinforced. Work on this is planned for the future.

As originally installed, the 40 burner blocks were made of cone 32 castable refractory, cast in place as the furnace was built. They gave pretty satisfactory life, but were replaced as the walls were rebuilt. These replacements were made with rammed material because it does not require as long a time to dry out and fire to maturity as does a castable. These rammed blocks have been rammed in place in the furnace which then was heated up to 2450 F and ready for rolling within six hours after ramming.

STRIP MILL FURNACE

As originally installed, the strip mill furnace was a typical triple-zone fired pusher type unit of conventional design except that the recuperator consisted of three 12-in. inside diameter alloy steel pipes, each 99 ft long, suspended in the flue leading to the stack.

The roof was a typical patented flat arch suspended type, constructed of super duty quality interlocked square cross sectional units. The soak zone and top heating zone flat section of the roof were composed of a special burned P.C.E. cone 33–34 super duty Missouri quality refractory, the remainder being regular super duty quality.

The side walls were built of a Pa. super duty quality brick. The suspended nose at the entry end of the soak zone was built of a 60 per cent alumina brick manufactured in Missouri.

This furnace was designed to heat 50 tons maximum per hour, of slabs for the 30-in. strip mill and was to burn a maximum of 750 gphr of Bunker C fuel oil.

The furnace and hot strip mill started operations late in 1949. In the beginning, production and fuel rates were not high as the crews had to learn to operate the new strip mill installation. As production rates increased, the soak zone roof, the flat roof section over the top zone and about eight feet down the sloping roof section, and the adjacent side walls exhibited a rather severe spalling condition. Nevertheless, this roof, with the aid of several patches, lasted for 1½ years. However, as the tonnage and fuel rates increased and went far beyond those specified in the original design, this spalling condition accelerated rapidly. This furnace has heated over 90 tons per hour for several consecutive hours and has been fired at a rate of over 1200 gal of Bunker C oil per hour. In July, 1951, the top roof section was entirely replaced. Three months later, it and an 8-ft section down the slope section were replaced again. Examination of the spalled brick revealed that while there evidently was considerable penetration of iron oxide or other contaminators, the hot face of the brick was not fused. However, the hot face had shrunk ⅛ in. to 3/16 in. in a horizontal length of 4½ in. The spalled pieces had broken off the brick at the line of the interlocking corrugations.

Figure 8 — Severe spalling and shrinkage of super-duty quality brick occurred in roof of triple-zone fired slab heating furnace.

Figure 9 — View is same as Figure 8 but six weeks after having been resurfaced by use of refractory cement gun.

Evidently the sharp corner at these corrugations produced a line of thermal weakness at this point, which was further aggravated by the stresses set up by the shrinkage action. Inspection of new brick used on this roof disclosed few or no signs of hair line cracks at the inner corners of the corrugations. Figure 8 is a view of this roof showing this spalling condition.

In February, 1952, it was again necessary to replace the top roof section and the first 8 ft of the sloping roof. Since there was a possibility that the previous roofs might have been heated up too rapidly, this installation was given 28 hours heat up time. For the first month of operation, this roof showed very little spalling, but after that time it started to spall badly. It lasted until July, 1952, at which time it again was replaced.

The above record has been given in some detail in order to show that we were having a constant battle with the spalling condition which, amongst other things, was costing valuable mill operating time. As will be noted, the flat roof section was replaced three times within 12 months. Other sections of the roof and side walls also required patching and replacement, but not quite as frequently as the top flat section.

In the following 13 months, it was again replaced three times. During this period of time, several at-

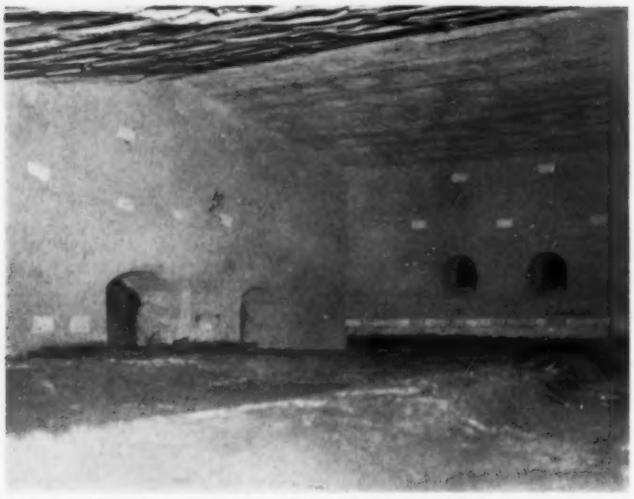


Figure 10 — Soak zone roof, side wall and burner wall rammed refractory installation gave better service.

tempts were made to reduce this spalling by trying such things as painting and spraying with special cements and coatings. Also, in one section, a different design of suspension and brick were tried, all with no true improvement.

In August 1953, a different grade of brick was installed. This was a super duty quality obtained from a Pa. manufacturer. This installation gave much better results. The spalling started later and progressed at a much slower rate. During this time, a refractory cement gun had been obtained and it was used to do a very effective job of building up and filling up the spalled areas. Figure 9 which can be compared with Figure 8, shows the roof after it had been coated for some time, and ready for another gun coating. By using this gun practice during four weekend shutdowns, this roof was made to last for 16 months.

At that time the flat roof section and 10 ft of the slope roof were replaced with a rammed installation, as described previously in the plate mill furnace discussion. This installation is now 22 months old and speaking conservatively, should last another year. During this time, it has been dressed and built up slightly six times by use of the cement gun. Some spalling has occurred but, as noted previously, in almost every case the hanging suspension brick spalled first before the rammed material adjacent to it tended to peel off. Figure 10 is a view of the soak zone section of this furnace showing the side wall, roof and soak zone burner wall as installed with rammed material.

While the above recites only the chronology of the roof, similar actions were taking place on the sidewalls, burner walls and nosing. At the present time, all the side walls, all three burner walls, and all of the roof except for the slope section at the charging end of the furnace, now are of rammed construction. In the case of the side walls, the original 22½-in. brick walls are replaced by 11½ in. of rammed material plus 2 in. of insulation. This has increased the width of the hearth so that it can accommodate longer slabs and produce additional tonnage for the mill. Also, the rammed roof resulted in a 10-in. increase in height from the skids to the inner face of the roof. Thus the rammed construction has produced increased combustion space. The thinner walls have not produced any increase in fuel consumption per ton of steel heated. One reason for this can be exemplified by the following. The brick roof construction allowed fumes and gases to pass up through it to the extent that one could not stay on top of it more than a few minutes without choking and gagging from the inhalation of the gases, and this in spite of the fact that it supposedly was sealed by a 1½-in. thick coating of plastic insulation. When one stands on top of the rammed roof, no such fumes can be detected. The installation is truly monolithic and has no joints or crevices along which temperature, gases or vapors can concentrate their attack.

This presentation covers only a small part of the refractories picture in mill reheating furnaces. It is a candid recital of some of the principal problems which we have encountered in our plant under our conditions of operations. It should be emphasized again that the extremely high firing and production rates and the drastic cooling down and heating up rates which are imposed on these furnaces play no small role in the demands made on the refractories used.

DISCUSSION

PRESENTED BY

F. H. WALSH, Assistant Superintendent, Structural Mills, Bethlehem Steel Co., Saucon Plant, Bethlehem, Pa.

JOHN S. MORRIS, Supervisor Construction, Central Maintenance, Lukens Steel Co., Coatesville, Pa.

R. RUSSELL FAYLES, Staff Assistant to Manager, Lukens Steel Co., Coatesville, Pa.

HARRY C. PAXSON, Superintendent—Masonry & Labor, Lukens Steel Co., Coatesville, Pa.

EDWARD E. CALLINAN, Superintendent—Masonry & Labor, Alan Wood Steel Co., Conshohocken, Pa.

F. H. Walsh: In the discussion of the plate mill furnace you mentioned a scale build-up and in one figure I think I saw evidence of quite a bit of scale on the top. How long are you able to run before you have to go down for repair or cleaning?

John S. Morris: I would like to ask with reference both to the refractory life of the rotating furnace, and also your strip mill furnace, the spalling you spoke of I believe is due to the weekend shutdowns where the furnace cools off and then you heat it up again. Has any comparative cost analysis been made between keeping the heat on the furnace during shutdown periods so that the refractories do not cool below spalling temperature, and the cost of replacing them?

R. Russell Fayles: That is about as frank a paper on troubles as I have ever heard presented. You gave instances in your paper of three repairs within a period of about three weeks on the one furnace. I do not recall any masonry man who ever admitted such unfortunate events in such rapid succession.

I wonder if the spalling that gave you so much difficulty on the brick could have, in any way, been caused by steam atomization of oil-firing. I am not sure, but I think your furnaces are oil-fired, in contrast to

gaseous fuels that are often used in larger plants, and it occurred to me that one of the prime sources of difficulty might be the steam used in atomization.

Another thing, the figures indicated that when you first went to the rammed construction it appeared that you were using two different types of hanger brick. One looked as if you used a portion of the old suspension as part of the suspension for the rammed material, and later as you went around, it looked as if you went to the corrugated brick.

Harry C. Paxson: I would like to ask in your application of the gunning material that you applied to the second furnace; how thick was the material applied? Was it applied when the furnace was hot, warm, or cold? Approximately what was the cost of the operation in comparison to any repair that you might normally have made?

Edward E. Callinan: Mr. Walsh asked how long we are able to operate the rotary hearth furnace before shutting down to clean or repair the scale hearth. I can summarize by saying we do not operate long enough.

The build-up on the hearth does present a problem, for with the automatic charging and discharging it must be kept within certain limits with respect to both elevation and flatness. Our practices in maintaining a proper hearth condition have varied. At one time, for example, we dug and dressed it every weekend. Present conditions demand that the furnace operate more turns and recently we have gone three weeks with only a minor dressing. A great deal depends on how much scale build-up accumulates and the actual size and weight of the slabs heated, since this latter point can affect flatness of the hearth.

Talking recently with our plate mill superintendent, he stated that he notes very definitely that when he has mill delays for roll changes or other reasons, he can see that the delay, that is, the excessive time the slabs are in the furnace, definitely causes more scale accumulation. A minor dressing may be the removal of a few high spots and leveling with a little scale. A major job entails skinning off the hearth to bring it down to a minimum elevation and then consolidating it by adding and tamping in scale.

Mr. Morris asked about the comparative costs of keeping the furnace hot over the weekends versus our present practice. As he said, this may have much to do with the amount of spalling which is encountered. Our practice has varied according to production demand and mill maintenance requirements. We have operated as low as 15 turns per week, but have operated 19 turns when it was not necessary to do any specific work on the hearth or other parts of the furnace such as the water seal or charging and discharging mechanism. When it is necessary to dig and dress the hearth, we always are pressed for time. The furnace may go off at midnight and six hours later we have men inside the furnace. To do this we play a water hose on the hearth, which also helps crack up the scale, and keep all four combustion air fans on full blast. And after the work is completed, the furnace may be lighted up and rolling started in 5½ to 6 hours time. We believe that such drastic treatment is the major cause of the spalling condition. We know this practice is undesirable but the economics of our operations—and this is the only way I can reply to the cost analysis part of the question—requires that we operate the furnace as much as we can in order to get the production demanded of the mill.

Mr. Fayles commented on the frankness of this presentation and asked two questions. To reply to the first comment, further frankness impels me to remark that some of the conditions cited were inherited by the personnel now responsible for our operations. In the case of the repeated failure of the interlocking baffle wall, it is only fair to say that it was subjected to temperatures in excess of design estimates and we did try to make it work, by making the revisions cited, before we gave up on it.

The relationship of steam atomization to spalling has been discussed and considered for years. Apparently its effect at high temperatures is less serious than at low temperatures, as when heating up is being started. We use steam atomized Bunker C oil and have never, more than momentarily, tried other fuels. So we have no other experience with which to make comparison.

He also asked a question about two types of hanger brick which he appeared to see in the illustrations. We have used only one type, a typical corrugated design. Apparently he was noting the I-beam type brick which carried the insulating fire brick assemblies in the original roof of the rotary hearth furnace.

Mr. Paxon asked about the thickness of the gunning material. Naturally, we find that the depth of the holes due to spalling or other effects, vary. When we gun patch we do not attempt deliberately to bring the furnace roof out to its original thickness. If we find some deep holes we will gun them and try not to get more than, say, three quarters of an inch to an inch applied at that particular time. We let this dry out good while gunning another section, and then come back and give it another light coating, but not trying in one operation to build the roof up to the original thickness. Optimum results with the gun are obtained, we believe, and it can be used with relative frequency, each time applying a relatively light coating.

I can not give any specific cost figures and can say only that a three man gun crew has a lower average rate than bricklayers and helpers, and that in keeping our two furnaces on the line, it is much quicker and takes no additional downtime as a brick patch job frequently would require.

SOAKING PITS

By

E. R. SULLIVAN

Turn Foreman

Blooming Mill Dept.

Bethlehem Steel Co.,

Sparrows Point, Md.

▲ REFRACTORIES are the major item in soaking pit maintenance cost. The high temperature refractories now being used in the pits at the Bethlehem Steel Sparrows Point plant are doing a satisfactory job and, consequently, few major changes have been made in the

construction materials. However, we are always striving to advance and are searching for improvements that will increase the time between general repairs and also further a reduction in costs.

All of the soaking pits at Sparrows Point are regenerative except a battery of five holes which are one-way top-fired recuperative pits. In the regenerative pit construction, the coping tile is semi-silica clay. The walls down to the slag line are two per cent alumina silica brick. Double arches supporting the bridge walls are also two per cent alumina silica. Below the slag line, basic metal-encased bricks are used on the inside face of wall to a depth of nine inches. Breasts are corbeled with metal-encased brick. First quality clay brick backs up the metal-encased brick in the side walls and the breast walls. Two protective courses of magnesite brick span the breast walls back to the checkers. The bottom consists of first quality clay brick covered with eighteen inches of coke breeze. Semi-silica clay brick composes the combustion chamber enclosure which consists of the regenerator roof, bulkhead walls and checker walls down six inches below the primary checker top level. However, in one section of the division wall, Missouri super-duty fire clay brick comprises the pier for the cover rail support. The lower part of the bulkhead and checker walls are composed of first quality fire clay brick. All of these outer walls are lined with insulating brick, and the regenerator roofs are covered with two and one-half inches of insulation.

Primary checkers with the 3½-in. square hole design are constructed of Missouri super-duty fire clay brick in the top five courses and first quality fire clay brick in the remaining courses. The checkers with the 5½-in. square hole design employ first quality brick completely. In the future, Missouri super-duty fire clay brick of the size used for 5½-in. hole design will be stocked for replacement in the top courses. First quality fire clay brick is used throughout the rider arches, secondary checkers and the flues.

Two types of covers service our pits—sprung arch and suspended brick. Semi-silica fire clay brick is used in all covers which are topped with 2½ in. of insulating material. Predominantly, suspended brick covers of Bethlehem Steel design are used. Hanger brick are employed in the suspension of the cover brick. As yet, covers have not presented any serious problems. We are experiencing a small amount of difficulty with physical damage, chiefly to the key brick in the four corners which fracture and pinch out (Figure 1). Probable causes are:

1. Cover setting too low in the seal allowing key brick to bear on inside curbing and fusing to same; however, seal sand sprinkled over the inside curbing helps to prevent the fusing action.

2. Scrap, hot-top brick or other material falling on inside curbing, fracturing brick when cover is lowered.

3. Jerking and jolting of cover may have a tendency to force cover frame out of its rectangular shape, causing fractures.

Hanger brick are made of extruded hard-burned fire clay. Repairs due to hanger brick failure are minimized where self-propelled cover carriages are employed. The few covers handled by cover cranes have experienced somewhat less success. In a few cases, complete rebricking has been necessary because the covers were dropped or rammed by a pit crane. At present, partial repairs to

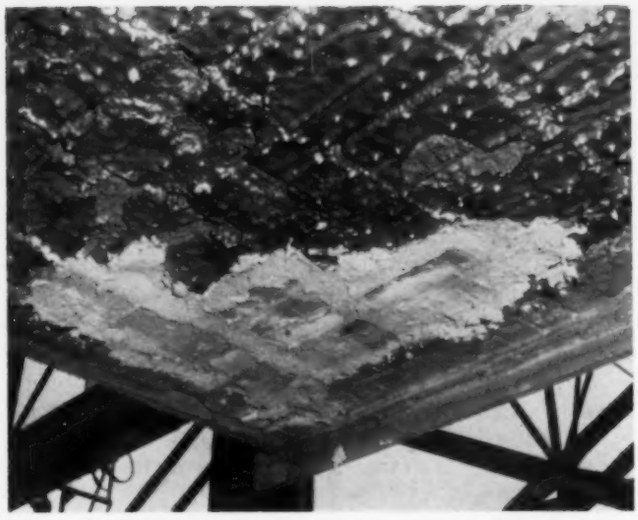


Figure 1 — On pit covers, trouble is sometimes encountered with the key brick on the four corners.

covers occur approximately every two years. Replacements average about fifteen per cent of the total brick.

The five sprung-arch covers on the one-way top-fired pits were originally bricked with a super-duty clay. They lasted over five years before being rebricked completely. Now all are semi-silica. The sprung arch covers on the small 7 x 9 ft regenerative pits fail mechanically in four years when the cast steel frames burn away.

Prior to general repair, a pit averages two repair jobs to the top of the pit, requiring twenty-four hours or less shutdown time. The curbing, when physically damaged, must be repaired to retain a seal for the cover. When the basic brick is practically all gone and the bridge walls excessively worn, a general repair is necessary on a pit that has been shut down by physically damaged curbing. The pits, on an average, operate three and one-half years brfore requiring a general repair. Usually, about twenty-five per cent of the high temperature refractories are replaced. All the basic must be replaced, necessitating underpinning the side walls, refacing the breasts and replacing the piers on the bridge walls. The arches and bridge walls usually must be replaced each time, especially in pits where the round-bottom hot-top ingots are charged. When ingots are propped against the wall, damages by impact, abrasion, gouging and spalling result. The hot-top brick fuses to the wall and often pulls out particles of the wall brick upon removal of the ingots. The side walls escape most of this punishment and can last through two general repairs with exception to underpinning and topping. Bottoms usually must be rebricked and whenever possible reclaimed clay stove checkers are used for this purpose.

With proper heating of the pits, the primary checkers can last through two general repairs. If replacement is necessary, only the burned upper courses and those checkers that may be blocked with slag are renewed. The refractory silicon carbide burner pipes last approximately seven years, while the bulkhead walls above the checkers can last fifteen years with some plastic patching around the burner pipes.

Regenerator roofs formerly constructed of two per cent alumina silica remained in service from seven to

Figure 2 — Dense super-duty fire clay was installed in the front bridge wall and the top four courses in the coping tile with improvement in service.

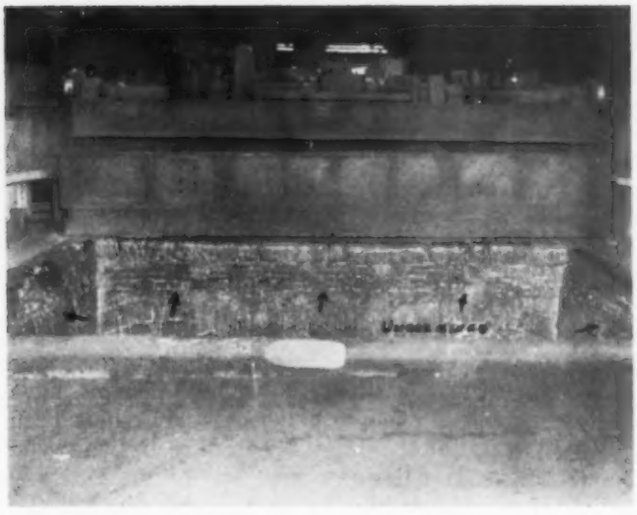


Figure 3 — Three walls of pit were renewed with two per cent alumina silica around the top.

ten years. Much of the thickness was lost by spalling, due to the expansion and contraction from heat variations. These roofs have been replaced with semi-silica fire clay brick. Now, instead of spalling, a solid glaze is formed over the whole roof. After ten years, these roofs are still in service and definitely are more economical.

Any improvement in the life span of the lower part of the pit can reduce costs tremendously. With this in mind, comparative tests on a small scale were made using blast furnace hearth and bosh quality, two per cent alumina silica, and metal encased brick to underpin the walls below the slag line in the same pit. Within six months, both the hearth and bosh, and special silica were pulled out by slag. The hearth and bosh brick shrunk and gave little resistance to the slag. The porosity of the special silica allowed deep penetration of the slag permitting it to be pulled out when slag was removed during the bottom making operation.

Presently, another comparative test is being conducted on a small scale with a dense sixty per cent alumina brick in one-half of the wall and metal encased in the other half. Installations in a newly rebuilt pit were made in March 1956. In such a short elapsed time, no conclusive observations can yet be made. The alumina brick though relatively high in cost is still much cheaper than metal encased.

The basic brick in the one-way top-fired pits lasted five and one-half year. The main reason for such good service is that hot-top ingots which are our greatest slag producers are never charged in these pits. The pit design, firing method, temperature control and longer heating cycle also have some bearing on minimizing slag in the bottoms.

Another experiment in progress to increase the life of the pit walls, which we feel are damaged primarily by leaning hot-top ingots against them, was the substitution of a dense Missouri super-duty fire clay in the front bridge wall (Fig. 2) at the top four courses under the coping tile. The other three walls (Fig. 3) were renewed at the same time with two per cent alumina silica around the top. After nine months of service, the Missouri super-duty fire clay shows a definite improvement. The hot-top ingot brick does not fuse to this wall and it shows less wearing than the other three walls. Results are very encouraging.

During the modernization program, silica sand stone was substituted for the two per cent alumina silica brick in the side walls of some pits from the slag line up to four courses from the coping tile. As yet, we have not found it to be of any advantage.

Plastics are being used successfully on small patching work. Once, the entire curbing was formed with plastic brick in place of curbing tile on a pit, but it did not appear to be advantageous.

Although the life of the basic brick has not been appreciably increased, the modernization of pits with the increased capacity and temperature control have aided in furthering the life span. Likewise, the bottom-making practice keeps slag at a minimum. At the same time more tonnage is passing through the pits and costs of refractories per ton of steel has been reduced.

DISCUSSION

PRESENTED BY

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EDWARD E. CALLINAN, Superintendent—Masonry & Labor, Alan Wood Steel Co., Conshohocken, Pa.

R. RUSSELL FAYLES, Staff Assistant to Manager, Lukens Steel Co., Coatesville, Pa.

E. R. SULLIVAN, Turn Foreman, Blooming Mill Dept., Bethlehem Steel Co., Sparrows Point, Md.

M. B. Deysher: It is evident that an excellent job is being done in achieving as much as five years service from the refractory construction in these soaking pits.

Referring to the semi-silica brick used in the suspended pit cover lining, have you experienced any spalling difficulties due to thermal shock caused by opening and closing the covers? I am also interested in knowing if you have tried any other type of refractory for this application.

Edward E. Callinan: I think you are to be congratu-

lated on the long service you are getting on the pits. I wanted to ask if you have temperature measuring devices installed anyplace in the pits? If so where are they installed and normally what temperatures are you running?

Secondly I want to know whether you have done any work with running the so-called dry bottom pits, that is, where the slag is not periodically removed but allowed to build up for some period of time?

R. Russell Fayles: This pit installation is a very unique one. I have been down to see it several times and there are some questions I would like to ask.

For the benefit of those that may not know it, these are converted regenerative pits, where 4-hole pits have been changed to 2-hole pits and ejector stacks have been put at the ends of the flues. They are really what you might call modern design regenerative pits, and they are doing a remarkable job on tonnage through the blooming mills served by these pits.

Have you ever used any fuel other than the almost-straight blast-furnace gas so common in your plant? Have you ever used any high Btu gas, and if so, have you had to curtail the charge in the pit by not having ingots in front of the ports?

I am familiar with similarly designed pits in the west, where they use high Btu fuel and are not able to put ingots close to the ports so they lose a lot of area when they are on the high Btu fuel.

E. R. Sullivan: Mr. Deysher asked if we had any experience in spalling of the covers due to thermal shock when charging or drawing the pits, and also if we tried using any other brick.

We do not have much spalling. The brick form a solid glaze over the entire cover. The only indications where it does look like it is spalled off is where the cover brick had rested on a tall ingot that sets too high in the pit and is then fused to ingot. When the cover is raised, the glazed portion is pulled off.

We have not tried any other brick in our covers.

Mr. Callinan wants to know where the temperature meters are installed and what type we use. We use a radiation pyrometer tube installed in the top of the cover, just off center. We try to keep the temperatures below 2480 F. We do not run any higher than that. Most of the steel is heated at 2430 F.

On the question, do we ever run any dry pits where we do not use any slag removing methods, we did that in our one set of pits and these pits did give us much trouble due to the fact we did not remove the slag. The slag cuts its way through the breasts, and since we did not have chill plates in the pits, cut down through the checkers and blocked off our flues. From then on we decided to continue our bottom-making practice to remove the slag.

Mr. Fayles wanted to know if we used anything else other than low Btu gas, and if we have tried any high Btu gas, and, if so, did we have to keep ingots away from ports.

We have never tried any high Btu gas. In most of the pits, we use blast furnace gas with a small amount of coke gas to raise the Btu value to 108. In the small pits that were not converted, 120 Btu gas is burned. Naturally, it has never been necessary to keep ingots away from the ports.

COMPREHENSIVE REFERENCE WORK ON COAL PUBLISHED BY MINES BUREAU

Knowledge obtained by some of America's foremost scientists in half a century of intensive research and laboratory study of the physical characteristics of coal has been compressed into a single volume published by the Bureau of Mines, of the Department of the Interior.

Entitled "Petrography of American Coals," the report presents detailed information on the appearance and properties of samples from 160 coal beds extensively mined in various parts of the United States. It also includes chemical analyses for each sample and gives results of many incidental tests and determinations.

The report, one of the most comprehensive of its kind and one of the most valuable ever published by the Bureau, will find wide use in industry and by many scientists, engineers, teachers, students, and others interested in the origin, composition and utilization of coal.

The report explains the Bureau's system of describing and classifying coals on the basis of microscopic examinations of extremely thin samples. This technique, developed by the late Bureau research chemist and world renowned scientist, Reinhardt Thiessen, provides information that is useful in all phases of coal technology—classification, mining, processing, and utilization.

Prepared by B. C. Parks and H. J. O'Donnell, technologists of the Coal Constitution and Miscellaneous Analysis Section at the Bureau's Pittsburgh, Pa., experiment station, the report contains a frontispiece showing in full color what science long has known—that coal is not always black, but may be predominantly red, orange, yellow, brown, or many-colored when thin sections are examined under a microscope.

The report is completely indexed by subject and author and contains 59 selected references on coal technology and many illustrations. It also includes geological and mine information on the source of the coal samples examined, descriptive vertical sections of coal beds sampled, and a map showing where the samples were obtained in relation to the coal fields of the United States.

Copies of Bureau of Mines Bulletin 550, "Petrography of American Coals," can be obtained *only* from the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C., for $1.75 each. The publication is *not* for sale by the Bureau of Mines.

....to review the problems of iron and steel production, leading operators of the steel industry met in New York City on May 22 and 23, 1957 at the general meeting of the American Iron and Steel Institute ....among the meetings were two technical sessions, one on finishing operations and one on blast furnace and raw materials....selections from some of the papers of particular interest are reprinted here....

AMERICAN IRON AND STEEL INSTITUTE 65th General Meeting

"PRESIDENT'S ADDRESS"

By

B. F. FAIRLESS

President

American Iron and Steel Institute

New York, N. Y.

▲EVERYWHERE these days, when the American economy is under discussion, we see one word being applied more than any other. Now one might think about it, and decide that this word is "inflation" but "inflation" would be my candidate for second place.

The word that is indeed dominant is the word *growth*. Everywhere, in individual enterprises, in industries, in our total economy, we find all America talking about *growth*. We are a nation *growing* in population, in better living for more people, in strength, and in promise for the future.

This great consciousness of growth is a fine thing. It gives all our people a dynamic sense of direction. It generates confidence in our economy and in our future.

But I wonder if there is not the possibility that it also may generate *over*-confidence. I saw a headline the other day referring to the "irrepressible growth" of our economy—and that phrase seemed to me to reflect a frame of mind that is spreading too rapidly over America.

This frame of mind is the bland assumption that our general prosperity has found the secret of perpetual motion—that the momentum is set, and all the American people have to do is go along for the ride.

Our economic progress has been so dramatic and so consistent over the past decade that it has been natural for such a concept to take hold. And indeed this is a carefree thought. If growth is irrepressible, then it cannot be stopped by shortsighted industrial or labor policies, or mismanagement of federal affairs, or public unconcern. It will go right on as a matter of course. No one will need feel any real responsibility for seeing that we stay on a sound and solid path. No one will need to exert the farsighted effort, wisdom and leadership that might otherwise be required to keep our economy growing—no one in business, labor or government.

Of course, the truth is that America's business and economic growth *never* has taken place of its own accord. It has been *accomplished*. And I give you the steel industry as Exhibit A.

This year, America and steel are beginning the second century of growing together. As we look back on the remarkable first century, we see 100 years of tremendous effort, enterprise and invention. In no other way, indeed, could this industry have given the nation the great foundation of steel on which it is built.

The role of enterprise was underscored at the very start of the age of steel. Henry Bessemer and William Kelly both were great pioneers. But while the one was knighted by the queen, the other died almost unknown. In that episode, history was giving this industry its first lesson in leadership. To have the great idea was not enough: behind it must be the ability to assess

and demonstrate its value, its potential and its human promise.

Constant invention by America's pioneer steelmen brought more and better ways to process more and better kinds of steel. Constant effort built organizations capable of marshalling men, talent and money to expand the industry and meet the rising challenges of each decade. Self-denial, savings, and the absence of confiscatory taxation made available billions of dollars to develop sources of raw materials. There was nothing automatic about such investments. They required accumulation of funds, risk-taking, and hard, responsible decisions in every case.

Aggressive decision-making, of course, was vital to the growth of the industry throughout the century. Every ton of new capacity came from a decision based not only on business sense, but on confidence in the future of America and Americans.

It was never easy to decide to adopt new methods that made equipment obsolete while it was still in the prime of its use. Certainly, it was not easy, during the 1930's depression, to decide to spend one billion dollars for new capacity. Nor was it simple, in that period, to assign millions of scarce dollars for continuing research and development. The expansion of the 30's was criticized as being "excessive," but the events of the years that followed proved it to be among the wisest decisions American management ever made.

So the steel industry has grown through its first century—through panics, recession, inflation, wars, and social and industrial revolution.

From less than one-third of England's production in 1870, to world's largest producer in 1890, to 40 per cent of the entire world capacity in 1957—this is America's record in steel. It came about not because of irrepressible growth, but because of the irrepressible spirit of the American people and the irrepressible determination of the industry to meet the nation's needs.

Certainly the past year has illustrated the increasing problems to be faced in seeing this growth continued. No one anywhere could know better than this group here today the hard decision-making, the planning and the work that went into the addition of five million tons of capacity in 1956. No one could be more aware of the enormous task of raising the one billion two hundred million dollars required to finance that addition.

No greater problem has ever faced the industry, in fact, than the current problem of getting money for growth in a period of mounting inflation coupled with highly inadequate provisions for industrial depreciation.

The past year has seen a major shift in demand among large steel-consuming industries. It has brought the crisis in the Mideast and the call for a rapid buildup of tanker construction. To meet these changing needs, a large part of the industry had to shift its product emphasis from the lighter strip and flat rolled sheets to heavy plates and structural shapes. Here again has been evidence that the steel industry does not grow along rigid, automatic lines, but must adapt often to meet changing national and world events.

This year, all estimates indicate an increase equaling, and possibly exceeding, the increase of last year. Plans for 1958 are no less ambitious. And we know that, over the long range, if the goal should be to keep output abreast of population, even at today's per capita use, capacity must be added at a rate of at least three million tons a year.

It is important to plan for this growth, but it is equally important to keep before the American people this clear fact: that the problems of paying for such growth are becoming increasingly critical.

At the root of these problems, very largely, is the incessant cost-price inflation of the past decade. The steel industry's modernization and expansion program during this decade, in which 42,000,000 tons of new steel capacity were built, would have cost roughly $5,000,000,000 at construction costs prevailing in 1946. Actually the cost has been higher to the extent that, for the same facilities, $3,000,000,000 of additional expenditures have been required.

At the same time, for all corporate business, and in terms of actual dollars, the profits from which a great part of growth money must come have been declining. From 1950 to the beginning of this year, the national income rose 43 per cent. The cost of compensation of employees, in actual dollars, went *up* 55 per cent—but corporate profits went *down* more than five per cent. Looked at another way, the share of the national income going into employee compensation increased from 64 to 70 per cent, while the share in corporate profits fell from 9 to 6 per cent!

Behind these figures—certainly with respect to the steel industry—is the clear fact that wage costs are rising far beyond increases in productivity. This fact may be all too evident to *us:* but there is urgent need for better public understanding of the problem.

But in the years since 1946, labor has demanded and obtained wage increases that leave no margin for sharing the benefits of increased productivity with consumers. These demands have steadily exceeded the productivity improvement—have been so heavy, indeed, as to force price increases on the industry in order to meet the wage schedules.

All such excessive demands on the industry are not only inflationary, but are ultimately canceled out in large measure by inflated dollars. Increasing harm is therefore done to the worker, the consumer, and the industry itself. The worker is affected because he will one day be living on a fixed dollar income set by social security and pension savings. The consumer (who, again, includes the worker) is affected because he must face constantly rising prices.

This is a situation of serious consequences, but unfortunately the problem does not stop even here. At our Meeting a year ago, I devoted the sum total of my remarks to the subject of depreciation. What I said then applies just as strongly now—in fact, *more* strongly because another year has gone by without relief. Replacement costs have gone up further, but replacement allowance under the Federal tax laws remains unchanged.

Steel companies, therefore, continue to recover only the original cost of worn-out equipment—even though the cost of replacing it has multiplied two to three times.

We must point out again the worsening effects of this tax policy. The steel companies are being required to use a greater and greater part of their so-called profits just to replace facilities as they wear out.

Funds that should be available to help insure growth for the future are going into the high cost of standing still.

This cost for steel is larger than would be necessary in many other industries that are not so heavily invested in long-life facilities. But this only means that industries like ours are caught in an extremely inequitable situation, because our capital is more heavily taxed away as it turns over more slowly through depreciation.

It also means that an entirely false impression of industry growth, in terms of profits, can be given to the public—unless the real nature of these "phantom profits" is made clear. There must be a wider and better understanding of the fact that a large part of what must be reported as profits subject to taxes is *actually* not profit at all, but an irrecoverable cost of doing business.

These, then, are reasons why it is hazardous for any Americans to be lulled into the assumption that growth is automatic. If labor leadership assumes that industry and the economy will continue to grow indefinitely despite constant cost-price inflation, there is mounting danger ahead. If needed legislation is ignored in the belief that growth is inevitable regardless of the depreciation burden, industry's expansion can be seriously impaired. If there is lack of public understanding of these basic problems, the problems will increase and the growth of our economy will be affected accordingly.

"A TAX ON WHITE HORSES"

By

ROGER M. BLOUGH

Chairman

United States Steel Corp.

Pittsburgh, Pa.

▲ THE future is beclouded by ideological hazards to which we are not yet fully alert, and against which our defenses are therefore dangerously weak. Among all of these, perhaps, none is more immediate—nor more dangerous in the long run—than the widely-expounded doctrine that big business is a menacing evil which must be atomized in the national interest.

If this issue of bigness is ever put before the people fairly, in clear-cut terms, for their decision, I have no fears whatever as to the outcome. Any straightforward proposal to impose an arbitrary political limit on business size—or on lawful business growth—would be emphatically rejected.

Unfortunately, this issue is not being presented to the American people in straightforward, clearly-defined terms. Rather it is being offered in a number of different disguises and in a surprising number of bills that are now before Congress. In its most dangerously deceptive form it is masquerading as an aid to small business in a rash of measures which would impose a "graduated" or "progressive" income tax on corporations.

At the moment, it appears that the proponents of this type of legislation are uniting their forces largely behind one of these bills in particular—a measure that was first introduced in the previous Congress by the distinguished gentleman from Texas, Congressman Wright Patman, and that is currently known in Congressional numerology as H. R. Seven. This bill is a major hazard to America's future. I do not question the sincerity or the integrity of the proponents of this bill; and while I do question strongly the logic and the wisdom of the measure, I want to commend its author for his frankness, at least, in voicing the hope that one of its major results will be to force the "voluntary dissolution" of large corporations.

I can think of no political device more cleverly designed to accomplish that exact result. So let us look at the terms of this bill:

Under the present system of quarterly "greetings" from the internal revenue collector, all corporations are taxed at the uniform rate of 52 per cent on all of their taxable income above $25,000.

But in place of this uniform rate, H. R. Seven would substitute a so-called "progressive" tax on a graduated scale ranging from 22 per cent in the lowest bracket—and rising through eight intermediate levels—to a high of 75 per cent in the top bracket.

Although this is, on its face, a revenue measure, it is not intended to increase the revenues of the Federal Treasury. Neither is it intended to diminish them. According to its proponents, its primary purpose is to aid small businesses by reducing their taxes substantially; and by shifting this burden of taxation onto the shoulders of what the author of the bill is pleased to call the "super-giant corporation." It would appear that a "super-giant corporation" under this bill is any corporation whose earnings before taxes amount to $37,000,000 a year or more. For companies above that level, the bill would increase the present tax rate; while companies below that level would have their taxes reduced.

This means that the taxes now collected from several hundreds of thousands of corporations would be diminished, and that the resulting deficiency supposedly would be made up by a corresponding increase in the taxes paid by a few hundred so-called "supergiants."

In fact, it appears that for every corporation whose taxes would be increased under this bill, somewhere in the neighborhood of a thousand corporations would have their taxes reduced—initially, at least.

So if the pocketbook nerve of the American people is as sensitive as our practical politicians have always believed it to be, we might logically expect that within the business community itself, the corporate vote would be a thousand to one in favor of the passage of this bill—even though the destruction of the "supergiants"—at which the bill is aimed—might seriously affect thousands upon thousands of small businesses by wiping out their biggest customers as well as the principal suppliers of the basic materials upon which these small businesses depend.

H. R. Seven is also ingeniously designed to appeal strongly to the public at large. The American people recognize that small business is the backbone of our national economy; and they want to see it grow and expand—in numbers as well as in size. In short, they

believe in aiding small business in any way that is legitimate, reasonable and fair. And to prove that this bill is fair, its supporters have the most convincing and—to me—the most utterly illogical argument you've ever heard. They say:

"If it is fair and just to have graduated tax rates on individual incomes, then it is equally fair and just to have graduated rates on corporate incomes!"

Yet this is about as logical as that time-worn vaudeville gag that Moran and Mack used to pull about the farmer who found that his white horses ate more than his black horses—because he had more white horses!

That is precisely the principle upon which H. R. Seven is based. By way of illustration, suppose that a small business has a hundred stockholders and earns a hundred thousand dollars before taxes. That is an average of $1000 per stockholder. And suppose a big corporation has a million and a quarter stockholders and earns a billion and a quarter dollars before taxes. That, too, is an average of $1000 per stockholder. Yet under this bill the big corporation would be forced to pay 75 per cent of its top-bracket earnings in taxes to the federal government, while the small corporation would pay only 22 per cent. Why? Well, not because the investors in the big corporation had made more money or could better afford it, but simply because there were more of them!

So if the author of H. R. Seven ever decides to change the rather lengthy title that this bill now bears, we would suggest that he merely label it—with simple truth—"A Tax On White Horses." For that, in essence, is what it is.

There is the basic fallacy in any proposal to levy a graduated tax on corporate income. Regardless of its justification, when a graduated tax is levied on an individual, it is based, at least in theory, upon his ability to pay. But a corporation is not an individual. It is a group of individuals who have pooled their resources and the skills to perform some service desired by their fellow men. And no tax that is levied upon a group of individuals, collectively, bears any relationship whatever to their individual ability to pay.

For example, a survey of United States Steel's Stockholders in 1953 showed that more than half of them were people whose total incomes were less than $5000 per year. That was less than the average annual earnings of the workers in our mills. Yet under H. R. Seven, these people would be taxed, collectively, through the Corporation at a top rate of 71 per cent on the basis of our earnings last year instead of at the current rate of 52 per cent. And after that, of course, they would also be taxed, individually, on any dividends they received.

On the other hand, the investors in many small, closely-held corporations are often people of considerable means. Under this bill, they might be taxed collectively—through the corporation—at rates as low as 22 per cent.

So even a cursory examination of H. R. Seven reveals these indisputable facts: That it completely ignores the basic principle of "ability to pay" which it professes to expound; and that it violates every concept of justice and equity—tax or otherwise.

Today there are more than 4,000,000 small businesses in this country, but less than 15 per cent of these are corporations. All the rest are individually-owned enterprises or partnerships. But while H. R. Seven would substantially reduce the taxes on small corporations, it does not even mention any other form of small business. So if this bill does provide any real and lasting benefits for small corporations—which I sincerely doubt—then it would seem on the face of these facts that it is designed to favor a few hundred thousand small corporations while ignoring more than 3,500,000 other small enterprises whose taxes would not be reduced. All of which hardly seems compatible with the doctrine of "the greatest good for the greatest number."

Even if we confine our examination of this measure to the small corporations who would be directly benefited by its terms, we find, I think, that it is something less than a blessing in disguise. At present all of these enterprises that have taxable incomes of more than $25,000 are paying a uniform tax rate of 52 per cent of their earnings above that level. So, taxwise, they are able to compete on equal terms.

Not so under H. R. Seven, however; for should this measure ever become a law, these small corporations would be divided up into six different tax brackets with rates ranging from 22 per cent to 54 per cent. So at each of these six different levels, these small corporations would either have a tax advantage over their more prosperous competitors or would be at a tax disadvantage in relation to their more favored competitors.

It requires no imagination at all, however, to perceive that this bill—by abolishing equality of competition, taxwise—would impose heavy penalties on business growth by corporations of any size—not merely by the so-called "super-giants" but by even the smallest business units in our national corporate structure.

So I think we may reasonably conclude that the widely-heralded aid which this bill would presumably afford small business is a dubious blessing, at best. In fact, the more we look at the measure, the more evident it becomes that the fundamental purpose of H. R. Seven is to force the dissolution of the larger enterprises, and to freeze the size of our smaller units at their present levels. It is, in fact, a "fragmentation" tax designed to break our whole business structure up into little pieces.

What if big business really disappeared from the American industrial scene? What small business would then be able to search the earth and develop the new sources of iron ore, or oil, or any of the other vital raw materials that our people must have in this second century that we are now beginning? And what small business would then be able to risk millions of dollars in the kind of research that produced a nylon or a T-1 steel, and that must yet unlock the innermost secrets of the atom and harness the rays of the sun?

But above all, where is the small business that will ever be able to build the gigantic and complex machines we shall need for our national defense? Where shall we find the great mass production lines that twice in the twentieth century, have proved to be the salvation of America.

In my opinion this "fragmentation tax" proposal is one of the most plausible and most deceptively dangerous measures that has yet been aimed at our industrial system. Unless the American people can be fully

informed of its hidden implications, its proponents may in time be able to build up a pressure for its passage that Congress will find irresistible.

Clearly this is not an issue with which any of us can afford to temporize; for if I were seeking to cripple the American economy and to sap America's powers of self defense, I could hardly hope to find a device so perfectly suited to my needs as H. R. Seven.

"BREAKING THROUGH THE COMMUNICATION BARRIER"

By
CHARLES M. WHITE
Chairman
Republic Steel Corp.
Cleveland, Ohio

▲ IN spite of the effort that American industry has made to tell its story, the typical man on the street is suspicious of big business; he is confused by labor-management issues; he has very little real understanding of the fact that his security, his job, his prosperity and his future are directly dependent upon industrial progress. He has even less understanding of the role of capital and profits in our economic system.

The situation has improved in recent years, partly because the general education level is rising; partly because we in industry *have* exerted ourselves to make clear our objectives, and partly because of the sheer impact of industry's achievements. But there is still a wide gulf of misunderstanding between management and organized labor, between industry and the public, and between industry and government. I think this is the most serious challenge confronting us today.

If the three great segments of our economy can understand each other, there is no domestic problem that cannot be solved, no reasonable goal that cannot be achieved.

It is encouraging that so much progress has been made in the field of labor relations. Management has accepted unions as a permanent part of our economic structure, and many labor leaders have come to respect management's sincerity as well as performance. Thoughtful men on both sides of the bargaining table know that the partnership-in-fact of American labor and management has built the greatest production machine the world has ever seen.

Industry leaders have accepted the responsibility for training, for improving working conditions and for raising productivity by investing in better tools and processes. Furthermore, as productivity increased, they have shared the benefits in the form of shorter hours and higher pay. As a result, the American laboring man has the best tools, the highest wages, the shortest hours, the greatest security and the highest standard of living to be found anywhere on earth.

Unfortunately, this understanding is not shared by many union members. How many men in your plants understand the relationship of profits to jobs and job security? Of productivity to wage increases? To prices? To the standard of living? How many understand the relationship of dividends to your ability to raise equity capital? In this area we have failed to communicate the facts to our employees, and many of our labor troubles in the past few years have stemmed from this failure.

Our failure has been even greater in our dealings with the public, and with the agencies of local, state and federal governments. I have deliberately linked the two, because I want to underline an omission that I believe is at the base of our trouble in these areas. We have forgotten, too often, that we in these United States are a democracy.

Behind every agency, every bureau, every office are the unseen and often unremembered people, the voters. Stripped of all sentimentality, the bare fact is that they control the destinies of this country from the ballot box.

Pressure groups and political tactics can influence the outcome of the vote for short periods of time. But in the long run the opinion of the majority prevails, and will prevail as long as our system of government endures.

With this in mind, it is clear that we are continuously accountable to the public, and if we are judged accurately on motive, method, performance and future plans, I have no fear of the outcome. As a group, the men of management in American industry are the economic conscience of the nation.

But if citizens are to act and vote intelligently, they must know the facts, understand the facts, believe the facts. Yet the average voter today knows little about economics, or about business methods and problems. When controversies arise between labor and management, it is easier for him to understand labor's point of view than management's, because "wages" and "working hours" are more familiar to him than "profits" and "productivity."

In working to establish a common meeting ground with the general public, as well as our employees, we must remember that the individual is the common denominator. When we can speak of business and economic problems in a language the average man can understand; when we can demonstrate the oneness of his problems and ours, we will have taken a giant step toward ending strikes, inflationary pressures, and unwise government interference.

I think these are reasonable goals, but let's make no mistake about it. To succeed, we will have to increase, drastically, the amount of time and money we spend in getting the facts and getting them across to the people.

It is a startling idea, but *we know very little about some of the most basic dynamics of our economy.* We talk and write a lot about them, but their true nature is still hidden in the frontiers of economic theory.

It is hard to say "I don't know" on vital issues. But it is the beginning of wisdom. It leaves us no alternative. *We've got to get the facts.*

I think we should do everything we can to encourage research in economics and economic sociology. We need precise knowledge in these fields just as we do in metallurgy or electronics. We need to remove the guesswork, and reduce economics to a working science.

But from the standpoint of communications, getting the facts is only the first step. Information alone is of no more use than iron ore in the ground. It must be refined and shaped into forms useful to the audience. And there, I think, we have failed worst of all. Even in those areas of technology and simple economics where we know whereof we speak, we have failed to develop a language that has meaning for the layman.

We talk, we write, we sow words broadcast across the nation, but we do not spend enough time listening to what we say. We do not hear how our words and meanings are twisted or misrepresented by the receiver. We assume that his vocabulary is identical with ours.

Several years ago we decided to set up a program to teach basic economics to our 7000 supervisors. It seemed like a simple project when we started, but in doing background research on the problem we came upon some facts that astonished us, and broadened our objectives.

Now this will be hard to believe if you have never investigated, it, but we found that there was no textbook, no high school or college course in business economics that could be adapted to our needs. The language was wrong, and the material was either too abstract, or downright misleading in its content or treatment.

Equally disturbing was the discovery that only a few public schools taught economics; that most economics "courses" were merely short sections in general social studies, and that very few economics teachers had firsthand knowledge of business and industry.

The situation was so bad we had to develop a program from the ground up. We ask the Industrial Relations Center of the University of Chicago to work with us in researching, writing and field-testing a set of materials.

We had allowed six months for the job when we began. It took us two years to complete it—two years to determine the principal areas of misunderstanding, to translate ideas into simple language, to develop visual aids when language proved ineffective, and to teach the teachers how to teach even this simplified set of facts and formulas.

But when we finished we had something of value. We found that when a supervisor took the course, his ability to understand and interpret economic data jumped an average of 40 per cent. Interest in this supposedly dull subject jumped still more. Men came to class early and stayed late. They came, even if vacation schedules conflicted with classes. They carried their new knowledge and interest not only into the job, but into their home and community. It was an expensive undertaking, but the improved performance of supervisors, alone, more than justified the cost.

We have learned something else, too. People are hungry for economic information if it is presented in an interesting and understandable form. We have field-tested the course with union groups, teachers, high school students and women's clubs, and without exception their interest has been high.

There is no question about it. The opportunity to break through the communications barrier is there if we will grasp it.

But we must never forget that programs such as these are only a beginning. We need more facts and a simpler business language. We also need a broader philosophy of communications.

In the most literal sense, a company's communications program should be designed to strengthen the bonds of mutual interest that hold our society together. It should relate the employee—whether he be company president or trainee—to his job, to his company, to his community, and to the important issues of the day. It should relate the company to the community, to the industry of which it is a part, to the industries it serves, and to the economy as a whole.

I believe it is our responsibility to promote prosperity as well as products; good citizenship as well as good business; good government as well as free enterprise and the advantages of creative capitalism.

My credo, reduced to its simplest form is this: There is no basic conflict of interest between organized labor and management, business and the public, or business and government. There is only the conflict growing out of ignorance and misunderstanding.

My proposal to you is equally simple: Let's get the facts, develop the language, and utilize *all* of the tools of communication to promote understanding and the co-operative spirit.

If we do, the age-old dream of a truly united people, going down the road of prosperity and happiness together, can be a reality at last.

"QUENCH AND TEMPER PROCESS FOR THE MANUFACTURE OF HIGH STRENGTH TUBULAR PRODUCTS"

By

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▲ THE purpose of this paper is threefold: (1) to focus attention on the tremendous growth that lies ahead for the petroleum industry in the United States and, consequently, for the manufacture of tubular products; (2) to emphasize the rapid and sustained trend to deeper wells for the production of oil and gas, with resultant increased demand for high strength pipe; and (3) to describe a new continuous heat treating process which economically raises the mechanical properties of ordinary hot rolled tubular products to meet the expanding market for superior strength tubular materials.

The consumption of energy derived from mineral fuels and water power in the United States has increased 424 per cent in the last half century, from 8.0 quadrillion British thermal units in 1900 to 41.9 quadrillion in 1955. Only two-fifths of this growth may be attributed to the rise of population.

The annual rate of growth in the demand for petroleum products in the United States has approximated 7.0 per cent in the past 50 years and 5.8 per cent in the past 25 years. It is estimated that petroleum will account for 46.8 per cent of total energy requirements

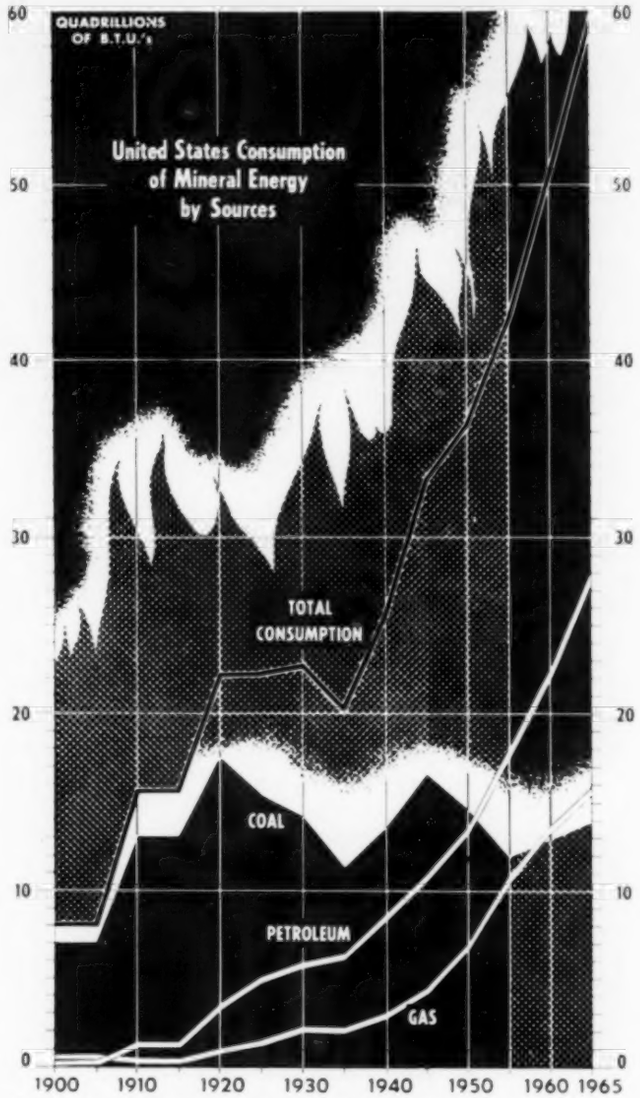


Figure 1 — Chart gives consumption of mineral energy in the United States by sources.

in the United States by 1965, compared to 42.4 per cent in 1955.

Natural gas, which supplied 3.2 per cent of total energy requirements in 1920 and slightly over 25 per cent in 1955, is forecast to be 26.5 per cent of the energy supply in 1965, with an annual rate of growth equal to 4.0 per cent. Production in terms of its crude oil equivalent in 1965 is forecast to be 7.4 million barrels daily, giving a combined daily oil and gas requirement of 20.4 million barrels. These data are compiled and illustrated in Figure 1.

ENGINEERING DESIGN FACTORS IN DEEP DRILLING

In setting a string of oil well casing, the major stresses considered are those of longitudinal tension or joint strength, external pressure tending to collapse the pipe, and internal pressure tending to burst the pipe. Since the performance properties of a casing joint of given wall thickness and type of joint connection vary as a function of yield and tensile strength of the material, improvement in performance properties generally must be accomplished by utilizing a steel of higher strength. If such material is not available, depth limitations imposed by casing strength can be exceeded only by adopting expedients such as subnormal factors of safety, by using pipe of heavier wall thickness, or by using casing with special end designs to increase joint strength. Add to this the fact that the cost of pipe failures rises sharply with depth of well and the incentives for utilizing higher strength pipe in deep well drilling programs become clearly evident.

An engineering study by Jones & Laughlin Steel Corp., based upon predicted operating conditions and specified design factors presented in a major oil company's 10-year projected deep drilling program, revealed that casing with the following properties would be needed to complete high pressure wells at depths extending to 25,000 ft:

1. Performance properties considerably higher than currently offered by the standard list of API weights and grades.
2. Heavier foot weights and greater wall thicknesses than presently available.
3. Yield strengths ranging up to 170,000 psi to develop adequate performance properties and to minimize the progression to heavier weights.
4. Couplings of greater outside diameter and cross-sectional area to maintain joint strength in the extra heavy casing weights.
5. Joints of special design for greater joint efficiency.

It is true that all of these factors are closely interrelated and that all must be considered simultaneously in designing a casing program for extreme depths and extraordinary pressure gradients. The key factor, however, is the availability of casing of adequate strength.

By common acceptance, the term "high strength" refers to oil country pipe not lower in yield strength than American Petroleum Institute grade N-80 (80,000 psi minimum yield) with respect to casing and tubing, and API grade E (75,000 psi minimum yield) in the case of drill pipe. By this definition, the high strength category includes not only grade N-80 and grade E, but also API grades P-105 and P-110 with minimum yield strengths of 105,000 psi and 110,000 psi, respectively. In addition, experimental grades for still higher strength levels are under development by pipe manufacturers in order to meet future service requirements projected by the drilling industry. As yet, there are no industry-wide standards controlling the mechanical properties of these premium experimental grades. Two such grades now being developed contemplate minimum yield strengths within the ranges 140,000/150,000 psi and 170,000/180,000 psi. For reference purposes in this paper these grades have been tentatively designated as "extra high strength" or EHS-140/150, and "ultra high strength" or UHS-170/180.

TABLE 1
Minimum Mechanical Properties of High Strength Grades

Grade	Yield strength, psi	Tensile strength, psi	Elongation, % in 2 in.
N-80	80,000	100,000	16
P-105	105,000	120,000	15
P-110	110,000	125,000	15
EHS-140/150	140,000/150,000	160,000/170,000	15
UHS-170/180	170,000/180,000	190,000/200,000	15

Thus, the minimum mechanical properties of existing and contemplated high strength grades may be set forth as in Table I.

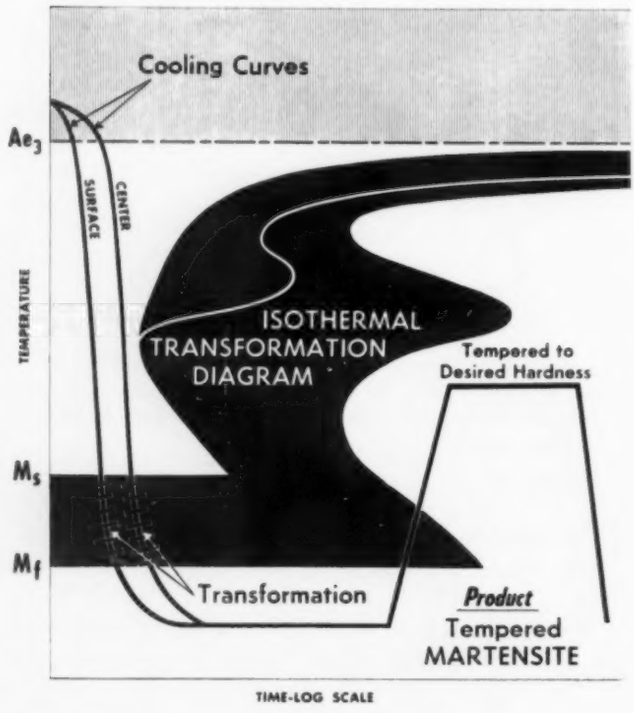
METALLURGICAL DESIGN FOR OPTIMUM MECHANICAL PROPERTIES

In considering the manufacture of high strength tubular products, questions arise as to how one should proceed to develop not only adequate yield strength but also satisfactory related properties at the most economical cost of both producer and consumer. For many years a manganese-molybdenum alloy steel has been widely used in producing normalized N-80 casing and tubing. At strength levels above N-80, however, one faces the problem of maintaining adequate ductility and toughness without resorting to excessive use of alloying elements.

It has been established, for example, that the ordinary mechanical properties of a particular steel—its yield and tensile strength, elongation, reduction of area, fatigue properties and notch sensitivity—are determined primarily by the microstructure of the steel. This statement is true also of the more fundamental variables—the flow and fracture stresses under various conditions of temperature, rate of loading, combined stress, and deformation. Composition effects these properties only insofar as it affects the microstructure. The microstructure, in turn, is determined primarily by the carbon content and by the phase transformations which the steel undergoes during heat treatment and, to some extent, during deformation.

It has become rather widely recognized that the optimum combinations of strength, service life and toughness can be obtained with steels having a microstructure of tempered martensite. Tempered martensitic structures are, as a class, characterized by relatively high ductility and high resistance to impact. Such steels definitely are superior in these respects to pearlitic or normalized steels of equivalent hardness and strength; conclusive evidence on this point will be presented in a later section of this paper. It is of interest, therefore, to examine the mechanism by which this desired structure may be formed in steel.

Figure 2 — Schematic shows transformation diagram for quenching and tempering.



When a piece of steel is heated above its upper critical temperature, for example to 1600 F, it is made completely austenitic. If the steel were held at this temperature indefinitely, for days or months or years, the structure would still be austenite. However, let the steel be cooled, as it is cooled in quenching, and the austenitic structure will then become unstable. That is to say, the austenite upon reaching some lower temperature will have a tendency to transform to other structures.

When the austenite is in these lower temperature ranges where it is unstable, it does not always transform to the same new product. Rather it is found that the product to which the austenite transforms is related to the temperature at which the transformation is caused to take place. As a concrete example, if austenite is cooled rapidly to a temperature in the range 350 F down to room temperature, it will promptly begin to transform to martensite. As indicated in the schematic transformation diagram, Figure 2 the cooling rate must be sufficiently rapid to avoid transformation of austenite while cooling through the temperature range in the knee area of the S-curve. This type of diagram is simply a convenient means of showing the time required for austenite to begin and to finish transforming at any temperature level below its range of stability.

THE NATURE OF THE QUENCHING PROCESS

Now consider the situation when a piece of steel is being quenched. The piece has been heated to an elevated temperature, such as 1600 F, and is then contacted by high pressure water. At that instant, liquid water cannot of course be in contact with the steel for the water is vaporized instantly. Anyone who has seen steel which has been sprayed with water emerge from a rolling mill at a temperature of say 1800 F cannot fail to be impressed with the manner in which droplets or even large pools of water roll around on the hot surface because of the thin cushion of steam between the water and the steel. In the same way, water in the quenching stream during the early part of a spray quench is separated from the hot steel by a small cushion of steam.

These considerations have been explored in great detail by Pilling and Lynch, who found three stages in the cooling of a cylinder by a liquid. The first stage is the stage in which the vapor blanket is present; heat transfer is by radiation and conduction through the vapor film and is relatively slow. The next prominent stage is a stage in which the surface of the piece is just cool enough to permit momentary contact of the liquid with the metal, causing immediate vaporization; the steam bubbles are carried away promptly by gravity and convection currents. This is the stage of most rapid cooling of the surface. The third stage is the one in which there is no longer any vaporization, the heat being carried out by conduction and convection cur-

rents until an equilibrium temperature is reached. Persistence of the initial vapor stage, or of localized vapor masses in the second stage, will inhibit the cooling of the areas affected and lead to localized transformation to structures softer than martensite. It is significant to note that the agitation which characterizes a pressure-spray quench effectively minimizes this type of difficulty.

One of the most effective methods of obtaining uniform rapid cooling is by the use of high velocity water sprays. Properly designed pressure-spray nozzles insure impingement of a relatively large number of small streams of liquid upon the surface of the steel which tend to disrupt, mechanically, the continuity of any gas films forming on the surface. Thus, high pressure sprays may be regarded as a means of making a given volume of water do more effectually the useful work of cooling.

In pressure-spray quenching, it is important to maintain water temperature as low as possible. An initial temperature of the water is increased, somewhat less heat must be taken from the steel to form steam and it is reasonable to assume that more steam will come in contact with, or become attached to, the surface of the metal at a given time. Such conditions promote non-uniform cooling since the action at the contact surfaces between the metal and the coolant is probably made up primarily of rapidly repeated cycles of steam regeneration, momentary attachment of steam to the metal surface, and its removal. With cold water, below 70 F, the vapor layer breaks down after a very short time. For intermediate temperatures, 70 to 110 F, the vapor layer breaks down repeatedly and reforms. This can be observed visually, with individual bubbles forming haphazardly at different points on the surface prior to the stage of nucleate boiling. Quenching in high temperature water, up to 160 F, is characterized by an unusually long persistence of a complete vapor blanket and consequent retardation of cooling.

It can be demonstrated also that the faster the water is moving when it contacts the steel, the quicker the steel cools. Laboratory studies have shown that spray droplets size decreases 25 to 40 per cent when injection pressure increases from 50 psi to 125 psi. Thus a spray nozzle system with a high injection pressure may be capable of producing substantially all martensite at the center of the workpiece, whereas a low pressure or still water quench may cause softer intermediate transformation products to form as well.

TEMPERING

Full hard martensitic steels in the as-quenched condition are seldom of any commercial importance due to lack of toughness and ductility and to the presence of high residual stresses. Therefore, in order to relieve internal stresses, decrease brittleness and restore ductility while preserving a desired amount of hardness and strength, as-quenched steels are tempered immediately after quenching by controlled reheating to a selected, subcritical temperature range. The higher the tempering temperature or the longer the time at temperature, the softer and more ductile the steel will become.

From the standpoint of the structure of the steel, tempering is mainly the process of coalescence of the carbides, accompanied by relief of stresses induced by the expansion in volume which takes place during the formation of martensite. This cannot proceed very far at room temperature even though martensite is conceived to represent a metastable super-saturated solution of carbon in ferrite, because diffusion is extremely slow at such temperatures. The effect of tempering begins to be noticeable at about 300 F and increases in intensity as the temperature rises.

DESCRIPTION OF JONES & LAUGHLIN'S QUENCH AND TEMPER LINE

While equipment employed in adapting the quench and temper process to tubular sections may vary in detail, any installation must provide for the basic operations of heating to austenitizing temperature, rapid cooling (quenching), and reheating for tempering. Auxiliary facilities at Jones & Laughlin include a sizing mill, roll and block straighteners, cutting and threading machines and equipment for inspection and testing operations.

Heating furnaces—The primary heating operation is accomplished in a fully sealed flat hearth, suspended roof, gas-fired furnace with inside dimensions of 52 × 43 ft. The furnace has two zones, a heating zone and a soaking zone, separated by a baffle wall approximately 20 ft from the charging end. The furnace is side charged by a series of individually driven conveyor rolls skewed at an angle of 30 degrees to impart a rotative action to the incoming pipe. The purpose of this is to insure uniform heating of the incoming tube around its circumference in order to minimize longitudinal warpage of the tube. That portion of the charging conveyor within the furnace proper is made of special heat resistant alloy rolls supported on water-cooled shafts. The shafts are cantilevered, with bearings and individual drives located outside the furnace shell. When the incoming pipe reaches a predetermined position inside the furnace, it depresses a flag switch which actuates the kick-off arms and lifts the tube from the entry conveyor onto the walking beam transfer.

The walking beam mechanism consists of 10 fixed and 10 moving alloy rails. These rails have pockets on 8-in. centers and are so arranged that the oscillating motion of the moving rails imparts a slight rolling action to the tube as it is lifted from and set down upon the fixed rails. Again the rotative action assures uniform heating and minimizes distortion. With each stroke of the moving rails, the pipe progresses 8 in. so that all pipe under 7 in. outside diameter travels on 8-in. spacing, while pipe 7 in. outside diameter and over travels in alternate pockets or on 16-in. spacing. All of the rails and the posts supporting the rails are made of heat resistant alloy.

The furnace is fired with 50 tempered-flame burners, of which 25 are located in each end wall. The burners each have a capacity of 1,500,000 Btu per hour and are suitable for either coke oven or natural gas fuel. Combustion air is furnished by a blower rated at 10,000 cfm at 8 ounces pressure. The furnace is so designed that the waste gases pass from the furnace chamber at the charging end. Temperature control is obtained by

automatic proportioning control of gas flow to the burners.

After a proper soaking period at approximately 1600 F, the pipe is deposited on a side discharge roll conveyor which feeds the pipe axially through the quench unit located adjacent to the furnace discharge door. Speed of this conveyor is variable from 10 to 200 fpm and the individual conveyor rolls again are skewed 30 degrees to impart rotation to the pipe as it passes through the quench unit, thus assuring the uniform quench action which is essential in attaining uniform hardness with minimum distortion.

Quench unit—The quench unit was conceived, engineered and built by Jones & Laughlin personnel. It consists of a quench head, two 1500-gpm submerged vertical pumps, necessary intermediate piping, pump pit and scale pit. The water supply is strained river water discharged at 120-psi pressure. The supply is arranged so that the pumps are fed from any one or a combination of three sources:

1. Piped direct from mill service water lines.
2. Gravity feed of water previously used for cooling nearby round mill furnace skids.
3. Recirculated quench water from the scale pit with necessary make-up from mill service lines.

The quench head itself consists of an annular feed pipe which supplies water to twelve longitudinal headers equally spaced about the circumference and extending equidistant in both directions from the annular ring. The longitudinal headers are 4 ft 6½ in. in length and each contains 18 nipple connections, on 3-in. centers, which are welded to the headers at an angle of 30 degrees from the vertical plane in the direction of pipe travel. Each nipple connection is fitted with an injector-type stainless steel nozzle (216 in all) developing an overlapping 50 to 60 degree solid cone spray pattern. Two quench heads are in use: one for pipe sizes 4½ to 7⅝ in outside diameter inclusive, and the other for pipe sizes 8⅝ to 10⅝ in. outside diameter. The free space inside the ring of nozzles is 13¼ in. in diameter on the smaller quench head and 17¾ in. on the larger unit. Time required to change from one unit to another is approximately one-half hour.

In quenching, as in many metallurgical processes, heat transfer is the rate-limiting factor for the process as a whole. In order to cool the internal surface of the heated pipe by water which is applied only externally, a certain critical linear velocity cannot be exceeded—unless somehow a more efficient quench unit design is made available to extract heat from the pipe at a faster rate. Consequently, linear speeds through the quench unit vary with pipe size and wall thickness. In current practice, popular casing sizes such as 5½ and 7 in. outside diameter with wall thickness up to ½ in. are being quenched at linear speeds in the range of 30 to 50 fpm. This is roughly equivalent to a quenching rate of 30 tons per hour. Larger pipe sizes and heavier wall thicknesses, including coupling stock, are processed at correspondingly slower speeds and production rates.

Temper furnace—After passing through the quench, the pipe continues down a runout conveyor, then on to a variable speed chain transfer rack approximately 50 ft long. This rack was installed primarily as a cooling rack for use when normalizing pipe in No. 1 furnace; it would not be required for an installation used solely for quenching. At the end of the transfer rack, the pipe enters No. 2 temper furnace, which is a duplicate of No. 1 high heat furnace. Here the as-quenched pipe is reheated and held for a predetermined time interval at a controlled temperature in the range of 900 to 1200 F, depending on composition, section size, and strength level desired.

Sizing and straightening—Upon discharge from the tempering furnace, the pipe is warm-sized in a 3-stand sizing mill to assure proper diameter and roundness. Linear speed through the sizing mill is approximately 150 fpm. Adjustments in elevation of the mill to accommodate various pipe sizes are accomplished by means of motor-driven, wedge-type lifting mechanisms located in the base. The pipe then crosses a 45-ft cooling bed leading to a 7-roll rotary straightener equipped with power-driven screwdowns. Straightener speed is variable between 60 and 240 fpm. Grade P-110 and experimental higher strength grades are given a stress relieving thermal treatment after rotary straightening in order to improve collapse resistance of the casing.

Magnetic particle inspection—To insure adequate control of quality in high strength specialty tubular products, facilities are provided for full-length fluorescent magnetic particle inspection of the pipe surface under near ultra-violet or "black" light.

High pressure hydrostatic tester—The function of this unit is to hydrostatically test high strength pipe in full length, including the threaded joint. In operation, the pipe is filled with slack water and both ends are capped power tight with an air wrench. One end of the capped pipe is fitted with a test plug which in turn is connected to a high pressure hydraulic system. The operator starts the testing cycle by pressing a button opening the check valve. The cycle is then self-regulating with intensifier valves actuated automatically until internal hydraulic pressure in the pipe reaches the specified level, up to a maximum of 20,000 psi.

PRODUCTS OF THE QUENCH AND TEMPER LINE AND THEIR PROPERTIES

While most of the quenched and tempered pipe produced thus far has been in seamless casing sizes, it is likely that use of the process will be extended to include high strength drill pipe, line pipe and tubing structures as well. In fact, the possibilities of producing all of these classes of tubular products already have been explored with encouraging results. At Jones & Laughlin, however, the major tonnage has been grade N-80 and P-110 seamless casing and coupling stock manufactured in conformity with American Petroleum Institute Standard 5A. Both regular (non-upset) and upset ends have been processed successfully with maximum wall thickness ranging up to 0.770 in.

Representative ranges of chemical composition for several quench and temper pipe grades are shown in Table II along with standard chemical ranges for conventional normalized grades up to P-105 level. The advantage of the quench and temper process is readily apparent in regard to conservation of manganese, molybdenum and vanadium. But one might logically ask these questions: How do the significant metallurgical properties of the quenched and tempered product compare with those of the more highly alloyed normal-

TABLE II
Chemical Composition of Various High Strength Grades

Grade	Heat treatment	Element, per cent				
		Carbon	Manganese	Silicon	Molybdenum	Vanadium
N-80	Normalize	0.40/0.46	1.50/1.70	0.15/0.25	0.16 min.	...
N-80	Quench and temper	0.28/0.35	1.00/1.35	0.15/0.25	...	...
E	Normalize	0.40/0.46	1.50/1.70	0.15/0.25	0.16 min.	...
P-105	Normalize and temper	0.23/0.29	2.40/2.75	0.15/0.30	0.15 min.	0.15 min.
P-110	Quench and temper	0.28/0.33	1.35/1.65	0.15/0.25	...	...
EHS-140/150	Quench and temper	0.28/0.33	1.35/1.65	0.15/0.25	0.30 min.	...
UHS-170/180	Quench and temper	In experimental stage chemical limits not established				

ized grades? Is a satisfactory degree of ductility and toughness retained at super-strength levels or must these desirable properties be sacrificed in the interest of strength alone?

Answers to these questions are found in Table III, which indicates that quenched and tempered pipe at the N-80 strength level possesses a higher elongation rating than normalized alloy steel of N-80 grade even though, in this case, the average yield strength of the quenched and tempered pipe is considerably above that of the normalized material. A similar situation is disclosed at the P-105 and P-110 levels of yield strength. Table III also indicates that the quench and temper process can be employed to obtain yield strengths on the order of 150,000 psi while retaining elongation values on a par with normalized and tempered P-105 grade. Experimentally, it has been possible to quench and temper a triple alloy steel to produce yield strengths approaching 180,000 psi and, at the same time, develop quite satisfactory elongation values.

Similar improvements have been realized in other properties, notably notch toughness.

Performance properties of quenched and tempered N-80 and P-110 seamless casing have been determined in accordance with the provisions of American Petroleum Institute Bulletin 5C2. This includes evaluation of collapse resistance, internal yield pressure resistance and joint strength. In all cases the quenched and tempered material exceeded minimum API requirements by substantial margins. Test specimens of N-80, P-110 and EHS-140/150 quenched and tempered casing also have been subjected to gun perforation—an operation carried out in oil wells using either bullets or a shaped explosive charge to pierce the casing wall in the oil zone. Again, the quenched and tempered material performed satisfactorily with no shattering, splitting or cracking around the pierced holes. In the past two years, considerably more than 100,000 tons of Jones & Laughlin quenched and tempered high strength casing have been used by the drilling industry without a recorded service failure.

Cutting and threading of quenched and tempered high strength pipe are no more difficult to perform than are the corresponding operations on normalized alloy steels at strength levels up to and including P-110 specification. Beyond this point, where hardness in excess of 330 Brinell is encountered, it appears that unless new machining techniques are devised it may be necessary to compromise between high hardness and good machinability and accept lower cutting speeds. However, additional work is in progress to determine the individual and interrelated effects of cutting fluid, tool material and tool shape in order to achieve optimum machine output and tool life when finishing the super-strength grades.

SUMMARY

This paper has presented evidence to support the following conclusions:

1. Petroleum products and natural gas will account for about 73 per cent of the total energy requirements in the United States by 1965. This implies a continued steady rate of growth for the drilling industry.

2. To meet this demand, the petroleum industry will need to drill a steadily increasing number of high pressure oil and gas wells exceeding 10,000 feet in depth.

3. Engineering design considerations require that an increasing proportion of high strength tubular products be used in implementing projected deep drilling programs.

4. The process of continuous heating, water spray quenching and tempering is an effective method for producing high strength tubular products to existing

TABLE III
Average Mechanical Properties of High Strength Grades

Grade	Heat treatment	Number of heats	Yield strength, psi	Tensile strength, psi	Yield/ tensile ratio	Elongation per cent in 2 in.
N-80	Normalize	636	93,213	125,848	0.74	23.0
N-80	Quench and temper	844	98,510	116,754	0.84	25.1
P-105	Normalize and temper	56	114,484	136,754	0.84	18.7
P-110	Quench and temper	110	127,665	145,341	0.88	22.8
EHS-140/150	Quench and temper	5	149,960	163,120	0.92	19.0
UHS-170/180	Quench and temper	2	177,930	196,020	0.91	32.0

API standards. The process also makes possible the production of super-strength grades which are required for extremely severe conditions encountered in deep, high pressure wells.

5. Mechanical properties and performance characteristics of high strength tubular products made by the quench and temper process are fully comparable with, and in some respects superior to the same properties determined on normalized alloy steels of equivalent strength. This conclusion is reinforced by satisfactory field performance rendered by more than 100,000 tons of quenched and tempered pipe under rigorous service conditions.

"TITANIUM—PRODUCTION AND USE"

By

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▲ THE "as-cast" surface of a titanium ingot is generally somewhat rough and porous. This surface condition is due to the molten metal freezing against the cold mold wall and usually extends a half-inch in depth. This surface must be removed or otherwise prepared, either in the "as-cast" ingot before forging or rolling or at some later stage in the processing.

Turning requires surface removal up to one-half inch or more and may be supplemented by spot grinding in some areas. This is expensive in relation to both man power and metal loss. The metal loss alone may average approximately 10 per cent of the ingot weight. This operation is receiving much attention from the standpoint of cost reduction.

Arc conditioning the "as-cast" surface is a method which holds real promise in this respect. A nonconsumable electrode, operating in an inert atmosphere or partial vacuum, is used to fuse the raw ingot surface to a depth of ¾ in. or more. This fusion penetrates to the deepest subsurface porosity and, on solidifying, results in solid surface metal. The ingot is then ready for rolling without the losses common to turning operations. Some local or spot grinding may be necessary to condition the surface completely, but it is usually of a minor nature.

PROCESSING

Titanium has a strong tendency to absorb oxygen, hydrogen and nitrogen, particularly at elevated temperatures. Furthermore, the mechanical properties in the finished product, especially ductility, can be adversely affected if processing temperatures are too high. It is, therefore, of prime importance to roll or forge at the lowest possible temperature, commensurate, of course, with the nature of the alloy being worked. Rolling and forging temperatures for the commercially pure and alloy titanium grades are shown in Table I.

TABLE I
Forging and Rolling Temperatures for the Commercially Pure and Alloy Titanium Grades

Grade	Nominal analysis	Processing temperatures			
		Ingot breakdown temperature, F	Final finishing—maximum temperature, F		
			Forging	Bar mill	Sheet mill
RS-40	Commercially pure	1800	1600	1550	1300
RS-55	Commercially pure	1800	1600	1550	1300
RS-70	Commercially pure	1800	1600	1550	1300
RS-100	3.0 Mn-1.5 Al	1800	1600	1550	1400
RS-110A	8.0 Mn	1800	..	..	1350
RS-110B	3.25 Mn-2.25 Al	1800	..	..	1400
RS-110C	5.0 Al-2.5 Sn	2000	1900	1900	1800
RS-120A	6.0 Al-4.0 V	1900	1800	1800	1550
RS-130	4.0 Al-4.0 Mn	1850	1700	1650	1650
RS-140	2.75 Cr-1.25 Fe-5.0 Al	1850	1750	1750	1550

Oxygen and nitrogen pick-up will generally be confined to the surface and, in the case of bars, billets or forgings, this surface should be removed by final turning, machining or other finishing operations. This contamination in sheet or strip products is generally eliminated by grinding or pickling a few thousandths of an inch from the surface in the finishing operation. Hydrogen, however, will penetrate considerably deeper. A frequent source of hydrogen contamination is acid pickling, unless very close control is exercised. This can be quite serious with small bar sections and sheet or strip material.

The commercially pure grades are fairly soft, and sheet product can be readily rolled around 1300 F. The alloy types, and especially those containing significant amounts of aluminum, such as five or six per cent, are quite stiff and may require temperatures in the order of 1800 F or higher. The products of combustion in fuel-fired furnaces can easily be a source of hydrogen pick-up, depending somewhat on time at these high temperatures as well as furnace atmosphere. Complete combustion and a "clear" furnace atmosphere are maintained to reduce this to a minimum, but even then some contamination may develop. This has not been proven completely, but there is sufficient evidence to warrant a preference for muffle type or electrically heated furnaces for heating prior to finish rolling of sheet products. With this in mind, several roller hearth electric furnaces with five zones of temperature control have been installed.

Likewise, in annealing operations, in view of the time required, which is often several hours or more, hydrogen contamination is again a problem, particularly with fuel-fired furnaces. Even annealing in bell-type furnaces with radiant tube and inner cover has shown sufficient pickup on some of the alloys to be troublesome. With some analyses, vacuum annealing is a necessity to obtain hydrogen values below 150 and 125 parts per million (ppm) on sheets and small bars respectively.

A vacuum annealing furnace, capable of handling sheets 48 x 144 in. up to some 5000 lb per charge, was installed in 1955 and has been in continuous use

TABLE II

Nominal Chemical Composition and Minimum Mechanical Properties of Some Titanium Grades, Pure and Alloy, Annealed and Heat Treated

Grade	Chemical composition, per cent						Annealed properties				Heat treated properties			
	C Max	Mn	Al	Fe	Cr	V	Yield strength, minimum, psi	Tensile strength, minimum, psi	Per cent elongation, minimum	Per cent reduction in area, minimum	Yield strength, minimum, psi	Tensile strength, minimum, psi	Per cent elongation, minimum	Per cent reduction in area, minimum
RS-40	0.20	..	..	..	..	..	40,000	50,000	22	..	...	...	..	..
RS-55	0.20	..	..	..	..	..	55,000	65,000	20	..	...	...	..	..
RS-70	0.20	..	..	..	..	..	70,000	80,000	15	..	...	...	..	..
RS-100	0.20	3.0	1.5	..	..	..	100,000	110,000	12	..	...	...	..	..
RS-110A	0.20	8.0	..	..	..	..	110,000	120,000	10	..	...	...	..	..
RS-110B	0.10	3.25	2.25	..	..	..	110,000	120,000	10	..	...	...	..	..
RS-120A	0.10	..	6.0	..	..	4.0	120,000	130,000	10	30	140,000	150,000	8	20
RS-130	0.10	4.0	4.0	..	..	..	130,000	140,000	10	30	150,000	160,000	7	15
RS-140	0.10	..	5.0	1.25	2.75	..	140,000	150,000	10	30	170,000	180,000	6	15

ever since. Such annealing is a regular operation on some grades of alloy sheet in all gages, and only in the lighter gages in others. To facilitate hydrogen extraction the sheets are all separated from each other by means of spacers at the supported end. The furnace can be operated at a pressure of less than one micron of mercury. The time cycle from charge to charge is usually about 48 hr, with the temperature at 1200 to 1300 F for some 25 to 30 hr. The vacuum system consists of one mechanical and three oil diffusion booster pumps.

OXYGEN-HYDROGEN-NITROGEN

Titanium, like many metals, and more so than some, has encountered numerous obstacles in its path to success over the past seven years or so. Normal difficulties, such as thickness control of sheet product, surface quality, variation in mechanical properties and fabrication problems all contributed their share of headaches. Even in view of these, hydrogen, until it was brought under control, has probably caused more real concern than all the others. In excessive quantities it tends to develop a condition of delayed failure somewhat akin to season cracking if nonuniform residual stresses are present. The actual mechanics of this phenomenon are not too well understood or accepted. Similarly, there is no sharp dividing line between a good or a bad product. It is generally accepted that hydrogen in excess of some 250 ppm is likely to cause trouble, and control was established on a permissible upper limit which is usually 150 ppm. Under this lower level, titanium appears to be free from this phenomenon; however, between these hydrogen levels, there is an area of uncertainty.

In this respect, gas analysis, including oxygen, hydrogen and nitrogen, while of more general interest in the overall metals industry in recent years, is of primary importance and an absolute "must" in titanium operations. The normal alloy analyses, such as manganese, vanadium, chromium, etc., are made by wet chemical methods. Aluminum is run wet or spectrographically, though the latter method is preferred. Nitrogen is also run wet, using the Kjeldahl method. Oxygen is presently run by the vacuum fusion method which is quite slow, while hydrogen is determined much more rapidly by the hot extraction vacuum technique which has made real strides in the past three years or so. A great deal of work has been done, and is still in progress. At the present time, hydrogen checks within plus or minus 20 parts per million should be satisfactory on a production basis.

Oxygen determinations, on the other hand, are considerably more elusive and, while the results obtained show good progress, they still vary considerably from one determination to another.

FLAT ROLLED SHEET OR STRIP

In the production of flat rolled sheet or strip, the ingots are either forged and/or rolled to slabs of the proper size for further conversion to hot band or sheet bar. Production of alloy sheet is generally limited to hand mills. Commercially pure titanium sheet is produced on both hand mills and continuous cold strip mills. This strip product has the advantage of more uniform gage and improved surface, while the hand mills offer more flexibility as to size, thickness, and quantities for special items. Hot rolling temperatures are closely controlled and held in the order of 1300 F for the pure grades, but may go as high as 1800 F for some of the alloy types, especially those high in aluminum. For the best mechanical properties in the final sheet, the rolling temperature should be under the beta transformation range, which is in the order of 1600 F for the pure material, but is raised with the addition of aluminum. Hence, the aluminum alloys, while being stiffer and requiring higher temperature, will also permit higher hot working temperatures without harm to the finished product.

Time-at-temperature should be held to a minimum for, as previously noted, gas absorption increases rapidly with the higher temperatures.

Furnace atmospheres which are free from combustion products are desirable to reduce surface contamination. Even with the best of care, some oxygen pick-up is encountered and it is necessary to remove a slight amount, such as 0.002 or 0.003 in., from the thickness at the final stage either by grinding or pickling or both and, at the same time, restrict any excessive hydrogen pickup.

Final annealing is usually performed in packs to obtain both mechanical properties and flatness. Very little can be accomplished by conventional roller or stretcher leveling as usually applied to fully annealed soft steel or stainless sheets.

Cold rolled commercially pure strip is processed on conventional four-high cold reducing mills after hot rolling and annealing. Scale is easily removed from the hot band by shot blasting, followed by acid pickling. Process annealing and pickling is quite successful in fused caustic with acid finishing. Four-high mills are preferred for the break-down rolling to around 0.080-in. or so, but the cold sendzimir mills are best for the subsequent reducing and finishing. A minimum of 30 per cent reduction between anneals is desired for best final product. Sheets are finished by annealing, pickling, slitting, and cutting them to length.

TYPES AND PROPERTIES

Titanium is produced in both commercially pure and various alloy compositions. Both are available in billets and bars. The pure types are used in the annealed condition, while the alloys may be either annealed or heat treated, depending upon final application. Heat treatment consists of quenching in water or air cooling from some temperature in the alpha-beta range, followed by aging for 1 to 24 hr between 800 and 1100 F, depending upon the mechanical properties desired and the ultimate use. Table II shows several commercial grades, both pure and alloy, together with their composition and annealed mechanical properties as well as heat treated properties for some alloys responsive to such treatment.

FABRICATION

Titanium has the versatility of the other constructional metals, and can be forged, drawn, formed, spun, welded and machined into various shapes and products. Precautions are necessary, such as preheating for some stretching and forming operations. Inert gas shielding is required for welding titanium to prevent weld embrittlement by contamination with oxygen and nitrogen. Proper tool selections, as well as speeds, are required for machining and grinding. Much research work has been published covering such fabricating operations and more is in progress.

APPLICATIONS

The aircraft industry is demanding high strength titanium sheet with nearly perfect flatness for supersonic plane and missile applications. This requirement will involve the solution treating and aging of special alloys. Since titanium is only about one half as heavy as steel, and many titanium alloys can be processed to strength levels comparable to alloy steels, this demand is certainly warranted. Several methods have been tried successfully on an experimental basis, but up to now no full-sized sheets of the order of 48 x 120 in. or larger, as desired by the aircraft industry, have been made in production.

TABLE III
Titanium Sponge Production, Mill Production and Sponge Prices

Year	U. S. sponge production	U. S. mill production	U. S. sponge price
1946	2 tons		
1947	3 tons		
1948	10 tons		
1949	25 tons		
1950	73 tons		
1951	496 tons		
1952	1073 tons	140 tons	
1953	2240 tons	1063 tons	$5.00 per lb.
1954	4858 tons	1293 tons	$4.72 per lb.
1955	7411 tons	1860 tons	$3.75 per lb.
1956	14,100 tons	5300 tons	$2.75 per lb.

FUTURE PRODUCTION

During 1956, industry shipped approximately 5300 tons of mill products, including sheet, strip, bars, billets, and other forms. On the basis of some 14,000 tons of sponge produced this indicates that a good quantity of sponge went into industry inventory as well as the government titanium stockpile.

Looking at present sponge facilities together with the additional capacity indicated in late 1957 or 1958, which should then approximate 36,500 tons annually, the resulting capacity could be in the area of 40,000 to 45,000 tons. By 1958–59, capacity for mill products could readily be at an annual rate of 25,000 tons depending on product mix.

With this level of production reached, and the trend for pronounced downward prices already apparent, it is only reasonable to expect further reductions over the coming years. This should permit a materially increased use in the civilian economy which is vitally essential if titanium is to establish a sound, permanent place for itself among the many metals in widespread use today.

"PROCESS AND QUALITY CONTROL FOR MANAGEMENT"

By

WALTER T. HAYTER

Process Control Metallurgist

The Youngstown Sheet and Tube Co.

Youngstown, Ohio

▲ THE Youngstown Sheet and Tube Co., has improved the efficiency of our operating units by application of a principle we call "continuity of production."

This is a method which increases productivity, production and yields, and enhances product quality available for shipment at practically no extra cost. In effect, it makes better use of equipment and manhours. Simply stated, this principle is that on any continuously producing unit, discontinuity of production during scheduled operating hours adversely affects costs, productivity and quality. Interrupted production results in less production per man and machine hours worked, or lower productivity, which is finally reflected in higher cost per unit of production. If such a condition exists for a long period of time, more producing units conceivably would be required to produce a given amount of material. Figure 1 provides evidence of the effect of downtime on productivity. This indicates a correlation between delays and productivity on the 54-in. hot strip mill for the eleven operating

months of 1956. Here, the curve indicates a productivity of about 1500 tons per turn at 26.5 per cent delay and a rather steady rise to 1740 tons per turn with 19 per cent delay. From this it appears that each one per cent downtime below 26 per cent provides an extra 32 tons per turn on this unit.

Discontinuity of production has a definite effect upon quality. This can well be demonstrated by its effect upon electrolytic tinned strip for use in making tin cans. This type of unit produces tin plate in coil form, with coils welded end to end to form a continuous ribbon. Delays or discontinuity of production for any reason results in overpickled plate, excessive tin coating weight, burned, stained and damaged plate, with the end result of more rejects and secondary plate. Another example is coiler delays on a hot mill resulting in cobbles in the mill, scrapped slabs, a poor surface and undesirable physical properties.

Maintaining continuity of production involves some rather detailed studies of causes of discontinuity, keeping in mind always the necessity of searching for basic causes. Delays generally may be attributed to one of four major causes—mechanical, electrical, operating or outside. Most time will be lost due to the larger, recurring types of delays such as bearings or spindles in the mechanical group, motor problems in the electrical group, changing rolls in the operating group or power failure in the outside group. However, the balance of lost time in each group consists of many small, recurring and non-recurring delays which can consume a considerable amount of downtime. The major groupings are useful for alerting those responsible for seeing that such delays do not occur. However, a detailed breakdown is necessary under each major classification for study and analysis of delay causes to minimize their recurrence.

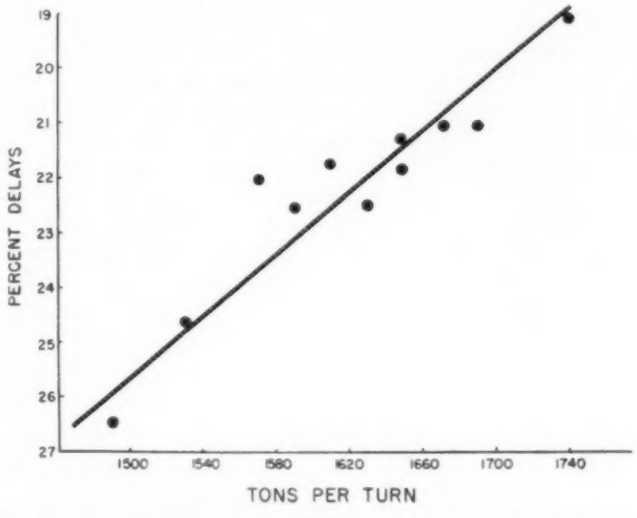


Figure 1 — As delays were reduced, productivity went up appreciably in the 54-in. hot strip mill.

Sources of the information to be analyzed are production and delay reports issued by each turn and crew on each major unit. Each type of delay, if not categorized by the recorder, must be placed in the proper mechanical, electrical, operating or outside group and then further classified. One word of caution may be given regarding inadequate descriptions or confused and mixed terminology. Too often, one type of problem can be called several things or, conversely, several problems are often really one. An example would be a delay which is attributed to "bad steel."

Other reports which are used are issued by the inspection and metallurgical departments. These provide the basis for determining the effect of discontinuity of production upon quality and performance. Accounting department records provide actual figures on productivity, costs, product mix (which often can be considered an assignable cause of both quality and productivity variations) and unit, slab-to-product and ingot-to-product yields.

With this rich background of information, simple statistical methods are used to predict expected ranges of variations in delays and percentages defective. From these, norms and units which indicate performance are derived for guidance of supervisory personnel. Crew, unit and departmental competitions are set up on delays, percentage increases in productivity and increases in yields. The matter of competition between groups cannot be overlooked in any attempts to increase efficiency. We firmly believe in the old fashioned, but psychologically sound, idea that most men take pride in their work and no man wants to be at the bottom of any comparative list.

We issue several periodic reports which we call our OK Product Reports. Their purpose is to create interest in having as much material as possible produced on any unit available for shipment to the next unit or the customer. The "OK" portion of the product does not include any rework or extra handling such as straightening pipe or assorting tin plate.

One "OK" report includes information on the classification of electrolytic tin plate after shearing. The three major divisions are as follows:

Classification one—The percentage of material sheared which may be shipped directly to the packaging department.

Classification two—The percentage of material sheared which is held for one or more defects.

Classification three—The percentage of material that is diverted to the reject piler, including material with holes, coil ends and scrap.

Results of these analyses are an increase in the percentage of "OK" plate from 64.1 per cent in 1954, to 67.1 per cent in 1955 and 67.7 per cent in 1956. The percentage for the last half of 1956 rose to 70.0 per cent. There is a considerable cost advantage to be gained in shifting as much plate as possible to the "OK" classification, and we have saved quite a lot of money in recent years by informing the shearmen and operators of their results. To determine the amount of prime plate thrown inadvertently into the reject pilers, we detail randomly selected lifts sheared by the different shearmen. Any decrease in the amount of prime plate mistakenly classified will automatically increase the percentage of "OK" plate, entailing no further handling costs.

Results of application of the "OK" theory to pipe are a three per cent "OK" increase due to decreases in crooked pipe, leakers and other defects. Another type of report concerns rejected coils, that is, coils which are rejected prior to processing on the next unit. These are analyzed as to cause and charged back to the producing unit. Several other "OK" theory adaptations

are used throughout the mill, all of which reflect quality and quantity being produced. Such reports are circulated widely, making use of graphic and written presentations.

Information gathered and presented daily and weekly is summarized in a monthly report on quality, productivity, delays and yield progress. In this report, we include monthly graphic comparisons between crews on delays and other mentioned factors, indicating causes, effects, trouble spots and some studies of particular problems. Information is placed upon master charts each month and the years' figures are presented with comparisons of previous semiannual or annual figures. Each department head, and foreman under him, receives a complete text plus all charts pertaining to his operation and a general picture of yields throughout the plant.

Copies of the monthly report covering all units are compiled and distributed to the general superintendents, district managers and the vice president in charge of operations. The most important feature of this report is that it provides a complete interpretation of the month's results compared with previous like periods, indicating cause, effect and trouble spots, and makes available to everyone from the vice president to the foreman a complete picture of process variables.

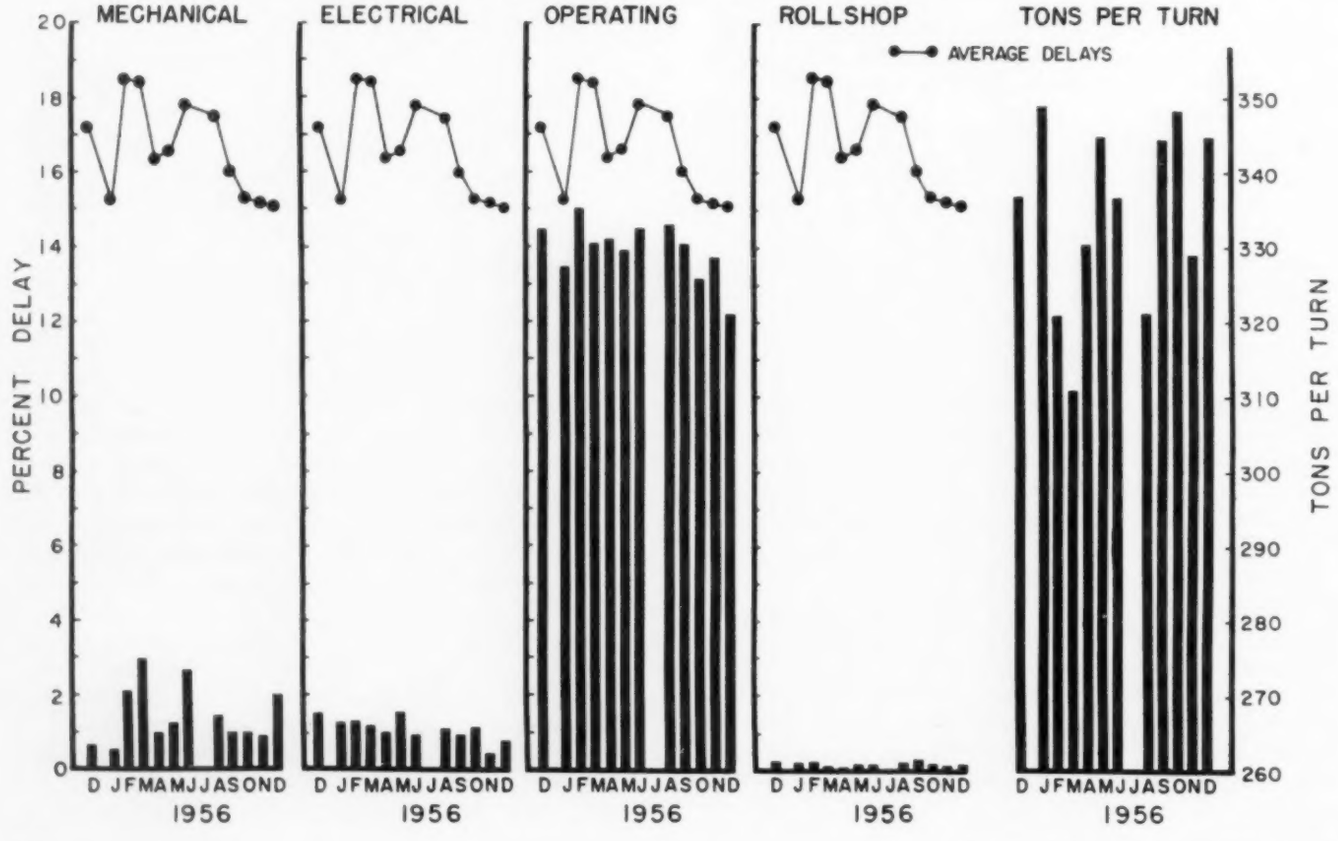
This report is divided into two major sections—one covers the steel plant and primary mills and the other includes all flat rolled products. Some items are reported in both, such as steel problems that effect flat rolled products and ingot or slab to product yields.

The steel plant report has been issued only since the first part of 1956 in its present form and is not as inclusive as the flat rolled audit which has been issued for several years. However, as the following list will indicate, we are covering and presenting a relatively large group of unit and category data variables in the steel plant report.

1. Ingot to product yields by unit and class of product.
2. Unit yields by product.
3. Productivities by class of product and total.
4. A group of open hearth figures such as:
   (a) The percentage of leaky pours for each separate shop.
   (b) Off heats by shop.
   (c) Causes and percentages of furnace switches.
   (d) Causes and percentage of diversions.
   (e) The percentage of hot metal used.
   (f) Tap-to-tap and other furnace time factors.
   (g) Chemical variations.
   (h) Tap to blooming mill delivery and pit charge time.
5. Conditioning productivities by type of conditioning.
6. Steel problems in flat rolled products.
7. Merchant mill products such as percentage inspected, diverted and rejected.
8. Delays on the blooming, merchant and pipe mills in detail.
9. A monthly comparison of OK pipe produced.

Our flat rolled monthly control report has been in existence for several years and is much more comprehensive and detailed than the steel plant report. Longer experience has enabled us to develop, in addition to greater coverage, effective and interesting

Figure 2 — Chart shows delay classification and production for five-stand mill in 1956.



methods of presentation. Some of the items covered in this report are:

1. Yield comparisons on slab to flat rolled products.
2. Unit productivity comparisons with the previous six-month averages.
3. The number of rejected coils per week charged to the various units.
4. Hot rolling.
   (a) Complete delays.
   (b) Number of cobbles per turn by crew.
   (c) Finishing and coiling deviations from mean aims of specifications.
5. Cold reduction: 5-stand:

Figure 2 demonstrates an actual cold reduction performance chart for 1956 taken from our monthly report. Figure 2 shows our general breakdown of delays compared, in each case, with the total delays, shown as a continuous line for each classification. Also shown on this chart are the variations in tons per turn during the year. Here, again, it will be noted that delays and productivities vary inversely.

6. Annealing.
   (a) Range of temperatures between thermocouples during soak period.
   (b) Control of furnace conditions by use of furnace temperature range.
   (c) Number of thermocouple failures.
7. Temper mills.
   (a) Rerolls by temper grade as per cent of grade and total tonnage.
   (b) Percentage of each temper rolled.
   (c) Delays and productivity by mill.
8. Electrolytic tinning lines.
   (a) M. E. O. delays by line complete.
   (b) Number of trimmer knife changes per turn.
   (c) Slowdowns, line stops, extra welds in total and by cause.
   (d) Control chart information on tin coating weights and spreads; these have been demonstrated each month for a long period of time with long term results demonstrating a decrease in average coatings in excess of aim on the #25 grade. The decrease has been gradual with a 0.007 lb per base box drop in the period from 1951 to 1956. A large part of this decrease was due to fewer line stops, slowdowns, delays and improved methods of controlling the variation in amounts of tin deposited across the strip. While 0.007 lb per base boy seems to be a small amount, it is worth roughly $7,000 per million base boxes.
   (e) Percentage of OK lifts.
   (f) Major causes of plate held.
   (g) Résumé of assorting room waste-waste and menders analysis.
9. Flying shears:
   (a) Productivities.
   (b) Delays
   (c) Per cent prime plate recovery from the reject piler.
10. Cold reduced sheet mill.
    (a) 4-stand.
        1. Delay breakdown.
        2. Number of size changes per turn.
        3. Per cent defective by cause.
        4. The percentage of broken welds on the mill.
        5. Productivities.
        6. Order segment sizes.
    (b) Temper mills
        1. Delays.
        2. Productivities.

Results of our analyses and efforts aimed at keeping our operators informed on their delays, productivities and yields can best be seen in a long range picture in which the periodic variations are minimized. A semi-annual report is made which summarizes problems and important factors shown in our monthly reports. This report also is sent to all interested parties from foremen to vice president. The main value of the semi-annual report is to provide long range information and to indicate changes not noted or not clear in more frequent presentations. It has also been found valuable for the appraisal of new equipment, installations and methods. We also include the results of projects and special studies made on various problems in these reports.

We make great use of graphical methods of presentation. Various types of charts are used such as bar, histograms, curves, control and fraction defective. Information is entered on translucent paper master charts and reproduced on an ammonium vapor photo copy machine. To call attention to particular charts, we duplicate those requiring attention in red and those deserving commendation in green; all others are done on white paper. Written interpretation of trends, excess variation and tabular or non-recurring types of data are also presented. Our format separates departments or units with charts covering a particular department following its written analysis. Reports are published by the 6th of each month. All superintendents concerned are shown the written and graphical data prior to publication and they are free to enter any comments they may have in the written text. Their comments are enclosed in brackets and identified as to source.

All of this work of analyses, presentations and publicity given delay and product quality information must produce some results to be worth continuing. One of the results of our studies has been the introduction of a preventive maintenance program. Such programs have been conceived and put into action in various parts of the mill based upon knowledge of equipment service required and expected life of such equipment. Inspections of mechanical and electrical components are regularly scheduled. Complete records are kept of such service, inspection and action taken upon recommendations made by both service men and inspectors. In order for such a program to be effective, the importance of good records cannot be overemphasized. Our studies have added emphasis to the setting up of a preventive maintenance program. The validity of such studies can best be demonstrated by a breakdown of the cost and amount of tonnage which can be lost when an important hot strip mill motor fails. The motor studied was a 900-hp hot strip mill motor. Failure of this motor would cost $966,120 for repairs and lost production at a downtime cost of $8,000 per hour in 120 hours. However, if $8,000 worth of parts

were carried in stock, as determined by records indicating what parts are likely to fail most frequently, this downtime cost could be reduced to $72,800. A decrease in cost even more spectacular could be achieved by making a preventive overhaul during scheduled downtime at a cost of only $1,200. It is easy to see the savings that can be made by keeping good records and planning downtime on the basis of these records.

Another result of our published work has been the correction of ill-conceived or out-dated methods and practices, including improvement of terminology toward better understanding. Changes in equipment, such as new types of automatic gages, recording micrometers, temperature and continuity controls, have been introduced to provide better and more useful information. Types of grease have been changed as a result of keeping track of bearing delays, selection of rubber rolls has been improved as a result of roll delay analysis on the electrolytic tinning lines, and the lubricity of rolling mill solutions has been varied because of strip surface studies. Improvements in practice have resulted from control studies such as hot mill finishing and coiling temperature specifications, better control of annealing furnace variables and lower tap to delivery time from the open hearths to blooming mills. Fewer delays have resulted in higher productivity and yields, better quality and better knowledge of the causes of complaints. At the end of each quarter of the year, we issue an analysis of all complaints received during that period. They are broken down as to source and type of complaint and comparisons are made with previous periods.

A great boon to the accumulation of data for management information is the use of tabulating cards and the electronic processing of data. We use different methods of approach according to the need. Perhaps one of our first successful applications was the determination of the status of orders in process and available for shipment. At the time of inception, we admittedly were not meeting our promise dates on tin plate shipments. Through the use of a status report issued bimonthly, we have acquainted personnel with order completion data in time to make necessary changes to meet our delivery promises. Another application is an in-process daily report which enables us to know the amount available for further processing at the end of a given process stage. In our sheet mill, we have set up a simple tabulating card system on completed orders which has provided some very valuable information. Weight records at various stages provide yields on individual orders, each specification or grade of steel; end use, such as for exposed or unexposed parts; industry such as automotive or appliance and many other variations. One thing that has struck us has been the informational byproducts to be gained from a simple tabulating record such as this. In building such a program, often the addition of some seemingly unrelated bit of information can provide byproducts out of proportion to the primary indications. Our latest applications of tabulating aids have been in the open hearths, rolling mills and conditioning docks through to the shipping floor, following each individual merchant mill heat. From these organized data, we expect to provide management with information regarding both quality, costs and yields. This application is definitely simple, making use of information already available but not used to the extent desired, due to its lack of organization. It has been a fact that the steel industry collects more data and does less with it than any other branch of our economic life. The sensible use of tabulating devices and programs using a simple statistical approach has corrected this situation somewhat, but not nearly to the extent that correction is desired or necessary or that will be seen in the future.

Out of these programs have come valuable data for use by product and grade, information as to mold size necessary for economic use of new facilities, and quality information necessary for successful application of steels to the various units.

Our project system, using large groups of data, has made good use of tabulating within the mill and also for such analysis as are conducted by the Institute. The project system is used to cover all things not routine in nature. A numbering system identifies the mill or unit being studied and progress reports are issued as data are gathered by the person or persons responsible for the project.

A large part of all our efforts described in this paper have been directed toward the increase of yields, both in product and productivity. In our thinking, yield increases mean more money in the bank, a larger quantity and better quality to ship. Judicious methods of increasing yields are synonymous with judicious methods of improving quality. This is different from the concept of increasing yields simply by cropping less or shipping as primes what should not be so considered. The methods we use involve surveys on processing and practices, correlating our inspection practices with knowledge of customers' needs and our performance in the field. Practice surveys are the cheapest and surest ways of attaining increases. The first questions to be asked are—are our standards archaic; are we using standards which are not realistically flexible; should the standards vary according to our processing, customers' practice or end use? Is too much being left to the judgment of melters, shearmen or other operators that actually should be investigated and decided upon by a staff group? Once these questions have been answered and constructive publicity given to the results, proper analysis and correlation of factors which can effect yields should result in establishment of norms or standards of yield performances. Here, again, competition between operators can provide a useful tool in their efforts to attain or exceed the norms.

Reports of yield performance on unit, product and ingot to product yields are issued at regular intervals at The Youngstown Sheet and Tube Co. These reports indicate needed action and reasons for undue deviation from the aims. Such publicity provided us with some rather spectacular results in 1956. The sums represented by these increases are worthy of note.

To summarize our thinking on the matter of process and quality control, we are convinced that efficiency, productivity, production and quality improvements can be made through the effective studies of and wide interplant publicity concerning production continuity and inquiry into processes and standards. This can best be done by using modern techniques of gathering, interpreting and presenting data. This involves the use of statistical means of data analysis such as control

charts, measurements of dispersion and correlations with the aid of tabulating equipment. Information gathered should be presented regularly in simple form, using graphic methods where possible, to everyone concerned from melter to vice president. All of this is done to create an interest in doing a good job—remembering that every man inherently wants to be proud of his work and that properly placed publicity will aid him in doing so.

"DEVELOPMENT OF CONTROLLED AIR DISTRIBUTION FOR THE BLAST FURNACE"

By

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▲ BLAST furnace operators have long recognized that uniformity is an important factor in blast furnace performance. In the past, attention has been directed principally to raw materials charged into the top of the furnace and, over the years, much progress has been made. Ores are now blended into grades of relatively uniform chemical analyses that vary only slightly from year to year. Coals are selectively mined, washed and blended to assure production of metallurgical coke of uniformly high quality.

Although more uniform chemical analysis of burden materials has resulted in improved blast furnace performance, channeling, slipping, hanging and other manifestations of erratic furnace operation continue to occur at higher wind rates. It has, therefore, become increasingly evident that further improvement in blast furnace production rates would be largely dependent upon a more uniform flow of gases through the furnace stock column. Thus, the accent on uniformity has now been directed not only to improvement of the physical strength, structure, size consist and distribution of raw materials entering at the top of the furnace, but also more recently to conditioning and more uniform distribution of another raw material—air—introduced into the furnace near the bottom.

Air is used in greater quantity than all other materials combined, and it has, therefore, been recognized as having considerable influence upon blast furnace operation. Historic improvements in the use of air have been the change from natural draft to forced draft at higher and higher pressures and volumes, and the change from cold blast to hotter and hotter hot blast. Dry blast and now wet blast, both designed to provide air at some uniform moisture content, have resulted in improved performance under certain conditions. Beneficiation, a term normally associated with ores, may also be applied to oxygen enrichment of air. Oxygen-steam as well as other gaseous additions are indicated to be attractive avenues still to be extensively explored.

This subject, however, is concerned primarily with uniformity—uniformity of air distribution to the blast furnace. There are literally hundreds of different sizes, designs and types of tuyeres and blowpipes, and every self-respecting blast furnace man had his own patented tuyere or at least a pet theory of some kind on how air should be introduced into the furnace. This was not without reason, for it had long been known that lining problems and blast furnace performance were often associated with poor air distribution, and it was hoped that changes in tuyere design would correct or alleviate the condition.

While good lining performance was experienced on some of the blast furnaces at Gary, others frequently developed hot spots leading to premature lining failure. A study of refractories, burden operating practice, furnace lines and other factors could not satisfactorily explain the repeated failures that occurred, generally on the same furnaces and in approximately the same general areas.

Inwall thermocouples had been installed on several furnaces approximately 20 ft. below the big bell. Thermocouples suitably encased in alloy steel protection tubes were installed projecting two to four inches beyond the brickwork so as to measure more accurately the gas temperatures at the hot face of the brickwork. It was observed that widely varying temperatures frequently occurred on furnaces having rough or erratic stock movement. High temperatures were an indication of higher gas velocity or flow in that area during the period at which the higher temperature existed. On some furnaces high temperatures and, it was assumed, high gas velocities persisted over longer periods of time. It appeared logical to assume that localized erosion of the brickwork could occur through the abrading action of fine particles of burden materials carried by a high velocity stream of hot gases. Examination of brickwork remaining in furnaces blown out for relining often gave evidence that this had occurred. Logically, then, uniform wear and extended lining life would be expected as a primary benefit of uniform gas flow.

Air distribution studies were started late in 1952 on No. 5 blast furnace at Gary. This furnace was selected because it was one of four furnaces having similar lines and dimensions. These furnaces have conventional lines; however, the lining is somewhat thinner than normal, and hot spots and premature lining failures had been a recurrent problem.

Initial attempts to measure air flow to the tuyeres were made by taking pitot tube traverse readings of the blow stock. These readings indicated that air flow varied considerably from tuyere to tuyere. In view of the unexpectedly large variation in the readings, consideration was given to the development of air flow.

It is recognized that various inaccuracies are inevitable in pitot tube measurements and, in fact, even more prevalent in this type of survey due to the procedure necessary to obtain measurements. Possible sources of error were sagging and bending of tube, turbulence in air flow and inaccuracies in centering of tube. However, to minimize the effect of these conditions, it was decided to take four readings at 90 degrees apart and consider the average of the four as representative velocity head for that particular tuyere.

Other pertinent data recorded were blast pressure, hot blast temperature, total blast and cold blast tem-

perature. For computing actual velocities from the data obtained, the approximate formula

$$V = 2.9\sqrt{Th}$$ was used,

where V = velocity in fps,
T = Absolute temperature, F
h = Velocity head in in. of water

From the velocity thus obtained and the area of blowpipe where measurement was made, the volume of blast was calculated by formula

$$\text{Vol. (cfm)} = VA \times 60$$

where A = area in sq ft

The figure thus obtained would be actual volume at the existing blast temperature if the pitot tube factor was unity and point of measurement was at the exact point of average velocity. Since neither of these factors are known, it was necessary to correct each volume obtained to standard conditions and to compare the total of all 12 tuyeres to the total blast to furnace during the survey. Each volume calculated was then reduced proportionately so that the total of the 12 tuyeres equaled the total blast to the furnace.

Air distribution surveys or measurements were made repeatedly on a number of furnaces of various sizes,

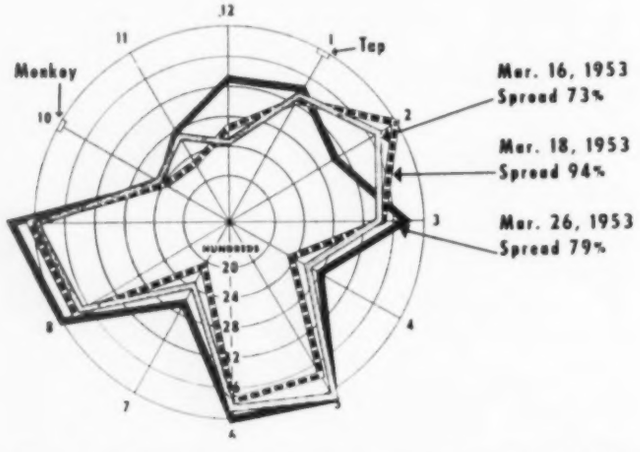

Figure 1 — Blast distribution is shown for No. 1 blast furnace before tuyere control.

not only at Gary Works, but also in the Pittsburgh District at Donora Works of American Steel and Wire Division of United States Steel Corp.

While it was recognized that the measurements were not completely accurate, it was obvious that the peripheral wind distribution of a blast furnace is far from uniform. The spread in wind volume from the tuyere having the lowest amount to the highest was, in extreme cases, as high as 94 per cent. Although the spread varied somewhat, the general pattern found on a particular furnace did persist from test to test. See Figure 1.

Further tests were carried out both at Gary and Donora in which an attempt was made to regulate and equalize the flow of air through judicious change of tuyere sizes.

By replacing 6-in. diam tuyeres with the smaller 5½-in. tuyeres at points of high flow, more uniform flow was obtained with a spread reduced to 58 per cent. On another furnace having all 6-in. tuyeres, the spread was reduced from 52 to 35 per cent by changing tuyere sizes.

That these changes in tuyere sizes and consequent changes in wind distribution did result in improved gas flow was evidenced by a change in inwall thermocouple temperatures. The spread in thermocouple temperature was reduced from approximately 425 F to about 200 F, and while the thermocouple temperature on the tap hole side continued to be higher, it was indicated that a notable improvement in gas flow had been accomplished. Although these changes were difficult to evaluate, some improvement was noted in blast furnace performance. However, the primary reason for investigation of blast furnace air distribution was to determine whether it might not be an important factor contributing to poor lining performance. Results of these tests did establish: (1) that peripheral wind distribution of a blast furnace is not uniform; (2) that the flow of gases through the furnace stock column is not uniform; (3) flow of gases up the stack is related to and influenced by the air input through the tuyeres; and (4) the wind distribution through the tuyeres and gas flow up the stock column can be changed. Although it had not been proved that lining life was affected by air distribution and gas flow, it did seem entirely logical that irregular gas flow could be an important agency leading to premature lining failure. Only a full scale test over a furnace campaign could indicate whether improvement in lining life would be realized.

DESIGN AND FUNCTIONING OF THE AIR PROPORTIONING SYSTEM

Once it was determined to proceed with an air proportioning system, the details were developed for a control system.

The problems faced can be classified in two general categories:

1. The development of a practical control system with the required control impulses, and,

2. Determination of the best materials and design for use in measuring and controlling the flow of high temperature blast, as well as withstanding the elevated temperatures developed during the back drafting procedure.

In formulating a control scheme there are several design features that have to be embodied in a basic system.

1. The system should operate with minimum hunting.

2. The hot blast control valves should operate as wide open as possible so that pressure drop and attendant higher blowing cost is held to a minimum.

3. The hot blast control valves should be designed so that all valves inadvertently going to full closed position do not result in enough restriction to cause dangerous pressure at the blower, or result in too serious a reduction of pressure at the tuyeres.

4. An overriding control should be provided to permit simultaneous opening of all hot blast control valves when desired, but principally for back drafting.

5. Individual tuyere controls should be provided to permit adjustments of an excess or deficiency of blast to individual tuyeres or groups of tuyeres when desired.

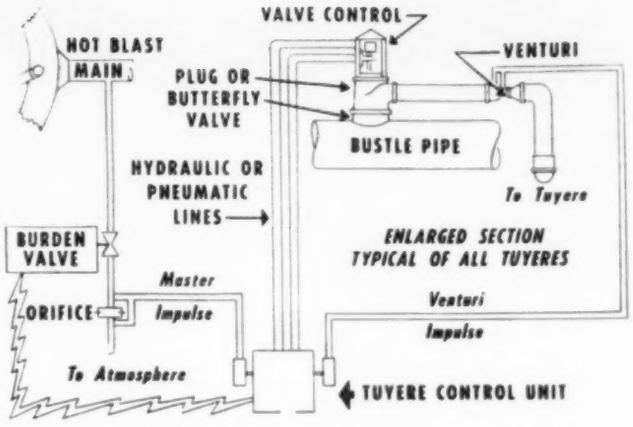

Figure 2 — Schematic diagram shows automatically controlled air proportioning system.

The fundamental control plan developed, shown for one tuyere in Figure 2, balances a differential pressure impulse generated by the tuyere's hot blast passing through a venturi section against a master impulse which is common to all individual tuyere control units. The master impulse is generated by using the differential pressure across an orifice plate. This orifice plate is located in a $^3/_4$-in. line which is tapped into the bustle pipe at one end and open to the atmosphere at the other. An automatically controlled valve, identified as the burden valve, is utilized in the line ahead of the orifice to establish control conditions by regulating the range of the master impulse. Originally, the burden valve was a manually operated valve, which was later motorized and incorporated within the automatic system. The burden valve is named as such because it regulates the magnitude of the master impulse to simulate the tightness or compactness of the burden materials within the furnace. Another way of picturing the burden valve is that it reflects the resistance of the counter pressure exerted by the burden materials against the pressure of the air entering the furnace through the tuyeres. The burden valve operates in a manner so as to vary the magnitude of the master impulse going to the individual tuyere control units to permit them to function within their controllable range.

In controlling flow, the system functions like any typical control system. If the flow through any tuyere changes, its venturi impulse goes out of balance with the master impulse. The control system then signals for the hot blast control valve to operate in the necessary direction to bring the system into balance again.

In addition to the basic air proportioning system, a supplementary system is incorporated which permits the hot blast control valves to operate as nearly open as possible, and also provides additional control for any exceptional degree of non-uniform flow. This supplementary system functions through automatic regulation of the master impulse by means of the motorized burden valve, which was mentioned previously. For example, if a deficient tuyere is not satisfied by its hot blast control valve going 98 per cent open, then the latter control system begins closing the remainder of the hot blast control valves, thus forcing more wind to the deficient tuyere until it is satisfied. Due to their design, the blast control valves hereafter will be referred to as plug valves. The closing of the remainder of the plug valves to aid the deficient tuyere is accomplished by reducing the magnitude of the master impulse through the partial closing of the automatic burden valve. This system also prevents all plug valves taken as a whole from going more than 60 per cent closed. When the plug valves taken as a whole reach the 60 per cent closed position, the automatic burden valve opens partially to increase the magnitude of the master impulse which then causes the plug valves to open to maintain the system in balance.

Each tuyere on the furnace has a control unit behind the panel. On the front there is a control cluster and a recording chart with three pens which indicate: (1) plug valve position, (2) venturi impulse, and (3) master impulse.

The large dial is used to set the type of regulation desired, i.e., uniform flow or a percentage excess or deficiency of blast. Actual practice has been to maintain uniform flow. Each tuyere unit is equipped with a control knob with a selection of automatic control, full open, full closed and neutral. Three light signals on each control, utilized to attract the operator's attention, indicate if the plug valve is fully open, closed or jammed. A master control, overriding all other controls, permits all the plug valves to be opened at once, principally for back drafting.

In laying out the blast-carrying elements of the system, particular attention was given to the materials and design from the standpoint of resistance to the effects of high temperatures. Venturi sections of nodular iron castings have been chosen as standard after trials of various other materials.

A plug type valve was chosen for control of the hot blast in the initial installation at Gary Steel Works. At that time, there was no butterfly valve design available which was likely to withstand the severe conditions, and internal water cooling was ruled out because of the possibility of undetected leaks. The plug valves have cast steel valve bodies lined with castable refractory. The plug is made of nodular iron. At present, nine furnaces of United States Steel Corp. are equipped for operation on proportioned air utilizing the plug type valve. Butterfly valves, which are now available, have better flow characteristics than plug valves, and secondary benefits are derived from savings in utilizing a smaller prime mover having less space requirement in the somewhat confined area where the valves are mounted. Normally, the air outlets from the bustle pipe are located at the bottom or the side of the inner circumference. In these installations, the air outlets have been relocated to the top or the side of the outer circumference of the bustle pipe. This design feature permitted the installation of the air proportioning system without necessitating a relocation of the bustle pipe.

One furnace within United States Steel Corp. is now equipped for operation with the butterfly type valve and several more will be installed during 1957.

CURRENT EVALUATION OF NO. 1 FURNACE CAMPAIGN

No. 1 furnace was the original air proportioning installation. The original equipment consisted of only the bare essentials required to control the flow. Through

the operation of utilizing only the very necessary controls, the details of the auxiliary components required for complete automatic control were determined. The controls on No. 1 furnace were modified considerably during the life of the furnace.

No. 1 furnace has completed a campaign of 1720 days of operation. It is evident that the furnace substantiated the deduction that it should maintain essentially normal production and coke rates with normally smooth operation through the major portion of the campaign.

The coke rate during the previous campaign of No. 1 furnace increased as the lining life increased, but during the presently completed campaign the coke rate decreased as the lining life increased. It is a normally accepted fact that the coke rate on a furnace will increase and production decrease as the furnace lining gets older. It is not meant here to imply that the coke rate trend for the last campaign of No. 1 furnace was due entirely to air proportioning. There were minor changes in raw materials and in operating practices which contributed to this decrease in the coke rate on No. 1 furnace. However, the changes which were made also aided Nos. 2 and 3 furnaces but did not halt the upward trend on these two furnaces. No. 1 furnace carried the average standard burden for the plant over its entire campaign.

The production on all furnaces decreased over the lining life. However, the expected decrease in production for the presently completed campaign on No. 1 furnace was less than normal. The significant point is that No. 1 furnace progressed through the present campaign with practice that deteriorated less than comparative campaigns.

Visual inspection of the lining during its removal indicated that the lining wear was more uniform than after previous campaigns. A hot spot did develop during this last campaign but its area was a great deal smaller than those which developed in prior campaigns, even after more days of service. Some cobblestone wear was observed in the lining which remained above the hot spot area. Normally, the area of greatest wear in a stock lining has been either pear-shaped, spiral, or horizontal in shape, but on this lining this area was pot-belly in shape. Although this hot spot area, which was discovered after 1554 days of operation, did develop, the practice did not deteriorate.

SUMMARY

From the standpoint of general operating conditions, uniform wind to the tuyeres results in definitely more uniform furnace operation.

The following points are significant:

1. Tuyere performance is more uniform. Peep-sight observations show more uniform action from tuyere to tuyere around the furnace.

2. The tendency for heavy lime formations at the tuyeres has been minimized. As the lime develops, the control valves open, admitting the proper amount of air which retards the lime formation.

3. Inwall gas flow temperatures around the furnace periphery are more uniform. Furnaces equipped with air proportioning are less subject to upset conditions and gas temperatures are brought into uniform range quicker, thus minimizing the production of off-grade iron and elapsed time of unsettled furnace operation.

4. At times when it became necessary to take the systems off control, the furnaces reacted by going into spells of rough operation. Usually the return to control had a settling effect. This indicates that when the blast is not proportioned, the path of least resistance is followed, resulting in some degree of channeling.

WANTED!

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Protection and Economy in One Hydraulic Fluid

▲ NINE months ago the hydraulic machinery of a hot strip conveyor and a butt welder at the Youngstown Sheet & Tube Co., East Chicago, Ind., was charged with a new emulsion-type hydraulic fluid. Based on operating data compiled during this time, the company reports over-all economies for both initial purchase and make-up, no fires when the fluid was exposed to sources of combustion, and a sharp reduction in maintenance costs.

According to the superintendent of maintenance at the plant, the value of a fire resistant hydraulic fluid to protect employees, equipment and plant facilities was long recognized by the company's lubrication and maintenance departments. With a part of Youngstown's hydraulic equipment operating in areas adjacent to hot metal, it was necessary to charge the hydraulic systems with a fluid that would not burn or explode in the event of line breaks or leaks.

Toward this end, a synthetic fluid (chlorinated/phosphated ester) was tested for close to a year in the central hydraulic system supplying a new hot coil conveyor and an upender. This conveyor consists of three coil upenders and a transfer car at the head-end, and one downender and transfer table at the delivery end. The hydraulic machinery at the head-end includes two 100-hp motors which drive the two 90 gpm pumping units accumulators and a tank of 1500-gal capacity. Pressure on all pumps averages 900 psi.

After a year of operation with the synthetic fluid, the lubrication engineer reported: (a) total cost for make-up losses was regarded as exorbitant, especially since the conveyor was operated at only 30 per cent of capacity; (b) the high specific gravity of the fluid (1.25) contributed to pump cavitation that required the replacing of blades and rings on three pumps; (c) exposure of the fluid to hot metal resulted in plant downtime due to formation of obnoxious vapors.

In explaining the latter disadvantage, it was stated that the coiled hot strip steel weighs about 5 to 6 tons. During production, if something irregular happened causing fracture of fluid lines, the fluid would be released onto the red hot strip. When the fluid contacted the hot steel, obnoxious vapors saturated the area and drove the employees away. Considerable time was lost before the atmosphere cleared sufficiently to permit repair of the hydraulic lines.

The need for a more suitable fire resistant hydraulic fluid prompted Youngstown to test Irus Fluid 902, a new water-based emulsion type fluid produced by the Shell Oil Co. This fluid, a mixture of water, petroleum oils and special emulsifiers will not burn when exposed to flame, molten metal or heated surfaces. In over 100,000 hours of field tests under all types of operating conditions, it has demonstrated lubricity and performance characteristics comparable with conventional petroleum fluids.

They tested Irus fluid by throwing quantities of it directly onto a hot slab entering the stands on the hot strip mill—on contact, the water content of the fluid turned into steam that quickly evaporated, while the remaining oil burned weakly for a few minutes and then went out. At no time was there any fire hazard, nor obnoxious fumes.

They stated that the water-base hydraulic fluid has proven itself in

Figure 1 (left) — Supply tank, pumping units and accumulators for the emulsion type hydraulic fluid at the hot strip mill coil transfer station. The fluid is pumped from this station to operate the upender, receiving and discharging elevators and the walker conveyor.

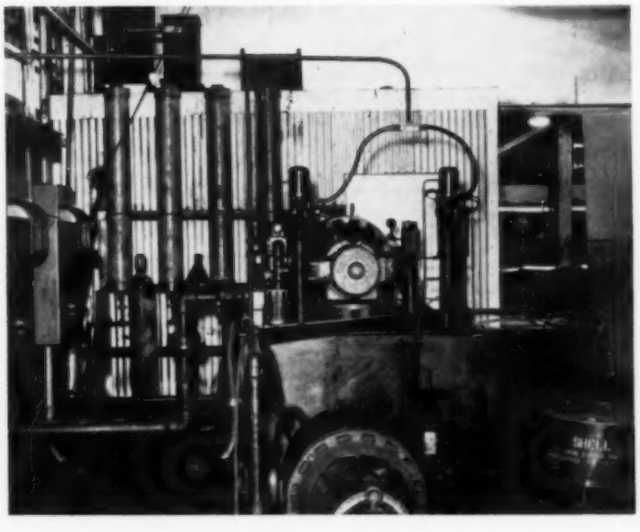
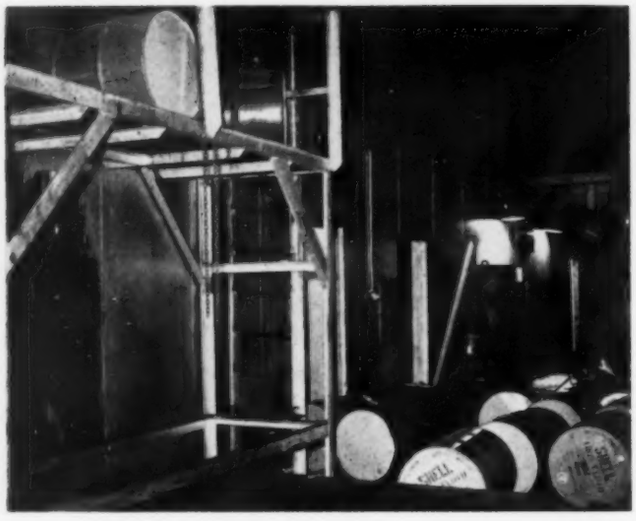


Figure 2 (right) — Downcoiler equipment at the hot strip mill is hydraulically operated. The upender in the background is handling a coil; the transfer car at lower right receives the coil from the upender and transfers it to the elevator (lower left) which lowers the coil on coil conveyor tracks. Arrows point to pipes which run under the floor to deliver the hydraulic fluid to working units.



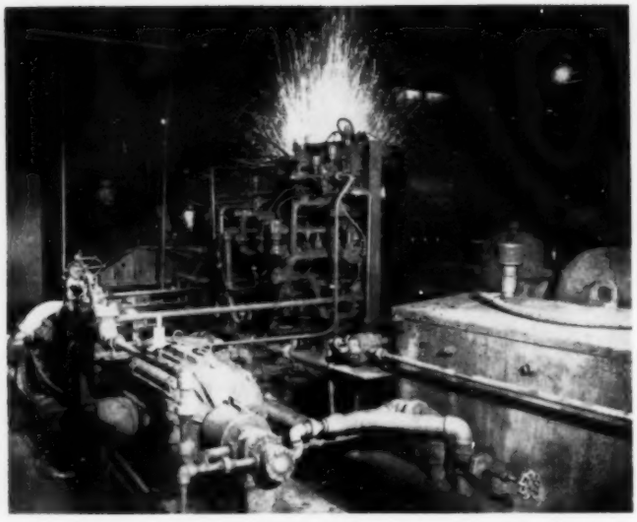


Figure 3 (left) — The hydraulic fluid supply unit at the down-coiler area at 54-in. hot strip mill. At the left is the supply tank enclosure. At upper left is a 55-gal drum of the fluid being emptied into the supply tank through a funnel. At lower right is the suction line leading to fluid pumps. Figure 4 (right) — Hydraulic unit at No. 2 continuous weld pipe mill and welder has at right the supply tank of hydraulic fluid, at left the pumps, and in the center the control valve panel.

the nine months it has been used at Youngstown:

1. A low one-third the cost of previously used fluids has brought maintenance figures back into line.

2. Its yellow color speeds up spotting of leaks. At the butt welder, for example, several hose leaks showed up when the equipment was charged with the fluid. As a result, make-up losses have dropped considerably.

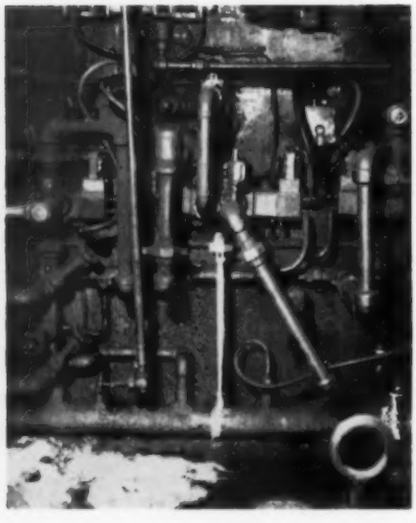
3. Twice since the fluid was installed, hot steel coils slipped from the unloader onto the hydraulic lines. Although there was much steam vapor, there was neither fire nor fumes.

4. Lower specific gravity has contributed toward reduced pump wear.

5. No new components were required in the changeover.

6. Hydraulic equipment runs cooler than with previous fluid. The bulk oil temperature has dropped 20 F.

Figure 5 — Section of control valve panel at No. 2 continuous weld pipe mill end welder unit. Since fluid is bright yellow in color, line leaks show up quickly. Line repair can be made promptly and thus keep make-up at a minimum.



INSTALLATION AND MAINTENANCE

Hot strip conveyor—In changing over to Irus fluid, the 1500-gal system of the head-end was thoroughly drained of all old fluid, parts were wiped out, pipe unions broken and lines blown out. The system was flushed for two hours with a standard paraffin oil, which was then drained out and lines again blown clear. Cylinders, accumulators and main connections were cleaned as well as the main supply tank.

A 1500-gal charge was added and operated for four weeks. This charge was then drained out and the last charge that was inserted has been operating ever since. It was not necessary to change delivery lines, pumps, valves or cylinders, O-rings, seals and gaskets, but intake lines were increased one diameter.

Switchover on the delivery end of the conveyor took place about six weeks later, the same procedure being followed.

At the present time, monthly make-up runs to 300 gal due mainly to renewable hose and couplings. Losses have dropped considerably with the use of the water-base fluid. The special rubber hoses that had to be installed when the synthetic fluid was used are now being replaced, as they wear out, with oil-resistant neoprene.

A 60-mesh partition screen is used in the reservoir to keep out harsh contaminants but no screens are used on the suction lines. Youngstown engineers feel that with a water-base hydraulic fluid conventional intake screens can cause excessive pump wear.

Water content of fluid is checked weekly by means of a 100-cc test tube filled half with fluid from a reservoir and half with cp ether. After being shaken up, the mixture is allowed to settle out. Percentage of water in the operating fluid is held to about 35 to 38 per cent; water loss if any, is made up with distilled water. Water has been added but once.

Butt welder—Hydraulic machinery activates a butt welder for making pipe joining the ends of two coils of skelp together for continuous production. The system has 300-gal capacity, two 40-hp motors with 40-gpm vane type double volume pumps on one end and a small pump on the other end for pilot valve operation. Three flushes with the fluid were necessary to remove all the old type fluid from this equipment.

TENTATIVE PROGRAM

Association of Iron and Steel Engineers

1957 Annual Convention

50TH ANNIVERSARY

HOTEL PENN-SHERATON PITTSBURGH, PA.

SEPTEMBER 23, 24, 25, 26

MONDAY, SEPTEMBER 23

9:15 am—BUSINESS MEETING—
9:30 am—ELECTRICAL SESSION—
9:30 am—COMBUSTION SESSION—
2:00 pm—MECHANICAL SESSION—
2:00 pm—OPERATING PRACTICE SESSION—

TUESDAY, SEPTEMBER 24

9:00 am—ELECTRICAL SESSION—
9:00 am—COMBUSTION SESSION—
2:00 pm—OPERATING PRACTICE SESSION—
2:00 pm—LUBRICATION SESSION—
6:00 pm—OLD TIMERS' DINNER—

WEDNESDAY, SEPTEMBER 25

9:00 am—ROLLING MILL SESSION—
9:00 am—LUBRICATION SESSION—
2:00 pm—OPERATING PRACTICE SESSION—
2:00 pm—ELECTRICAL SESSION
7:00 pm—FORMAL DINNER—
10:00 pm—DANCE—

THURSDAY, SEPTEMBER 26

9:00 am—COMBUSTION SESSION—
9:00 am—MECHANICAL SESSION—
2:00 pm—OXYGEN SESSION—
2:00 pm—ELECTRICAL SESSION—

TECHNICAL PAPERS

"Standardized Component Parts for Heavy Duty Mill Type Cranes," by Myron R. Bowerman, Director of Research, and Elvin R. Madison, Research Engineer, The Alliance Machine Co., Alliance, Ohio

"Increasing Open Hearth Capacity by Use of Light Weight Ladle Trolleys," by F. C. Schoen, Chief Engineer, Alan Wood Steel Co., Conshohocken, Pa.

"An Automatic Gage Control System for Tandem Cold Mills"

"Open Hearth Fuel Atomization with Reaction Type Jet Burner," by G. W. Hinds, Development Engineer, and A. L. Hodge, Staff Engineer, Linde Co., Div. of Union Carbide Corp., Newark, N. J.

"Accelerated Firing Rates in Open Hearth Furnaces," by E. T. W. Bailey, Chief Combustion Engineer, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

"Trends in Steel Mill Power Plants," by Howard G. Kitt, Senior Power Engineer, and Robert W. Worley, Chief Power Engineer, United Engineers & Constructors, Inc., Philadelphia, Pa.

"Magnetic-Flux Gas-Shielded Arc Welding," by J. E. Dato, Manager Eastern Region, Electric Welding, Linde Co., Div. of Union Carbide Corp., New York, N. Y.

"Railroad Car Rebuilds and Repair at Kaiser's Fontana Works," by A. B. Stoker, Foreman, Car Repair Shop, Kaiser Steel Corp., Fontana, Calif.

"Planned Maintenance Techniques for a Hot Strip Mill," by James R. Kennedy, Maintenance Foreman, Hot Mill Mechanical Dept., Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"Designing of a Large Tonnage Continuous Casting Plant," by Rufus Easton, Manager, Continuous Casting Section, Freyn Dept., Koppers Co. Inc., Pittsburgh, Pa., and Harold E. Skelley, Power & Fuel Engineer, Engineering Dept., Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.

"The Replacement of Steel Mill Plant and Equipment with Present Depreciation Reserves," by W. T. Hogan, S.J., Fordham University, New York, N. Y.

"The Dollars and Sense of Pickle Liquor Treatment," by James S. Joseph, Sales Engineer, and Elbert T. Culver, Senior Process Engineer, Chemical Dept., Koppers Co. Inc., Engineering and Construction Div., Pittsburgh, Pa.

"Electrical Advances Can Reduce Installed Cost," by E. E. Vonada, Product and Application Specialist, Reliance Electric and Engineering Co., Cleveland, Ohio

"Protection Against Prolonged Delays on Main Drive Electrical Equipment," by H. H. Angel, Electrical Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

"Selection of Electrical Equipment for Temper and Skin Pass Mills," by J. E. Peebles, J. J. Remley and R. B. Eggleston, Steel Mill Engineers, Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

"High Velocity Gas Stress Relieving Furnace," by Edward M. Yard, Chief Project Engineer, Mechanical, John A. Roebling's Sons Corp., Trenton, N. J.

"Fast Annealing of Sheet-Strip Coils with Helium Injection," by J. D. Keller, Partner, Associated Engineers, Pittsburgh, Pa.

"One-Pass Continuous Annealing of Tin Plate Stock"

"Modern Methods of Iron Ore Reduction," by H. W. McQuaid, Consulting Metallurgical Engineer, Cleveland, Ohio

"Techniques in Rebuilding a Blast Furnace," by C. F. Bessent, Supervisor, Mechanical Maintenance Dept., Bethlehem Steel Co., Sparrows Point, Md.

"Distributing Raw Materials in Blast Furnaces," by Henry W. Campbell, Chief Engineer, Interlake Iron Corp., Cleveland, Ohio

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"Important Considerations in the Design of Modern Centralized Lubricating Systems," by G. C. Almasi, Materials and Standards Engineering Div., Crucible Steel Co. of America, Midland, Pa.

"The Importance of Pumpability and Heat Stability in Industrial Greases," by Wm. A. Magie 2nd, Vice President, Magie Bros. Oil Co., Franklin Park, Ill.

"Application of Stretch Reducing of Tubes for Greater Production and Economy," by William Rodder, First Vice President, The Aetna-Standard Engineering Co., Pittsburgh, Pa.

"Some Practical Solutions to Hot Mill Problems," by R. A. Smith, Assistant General Foreman, and A. D. Patton, Assistant to General Foreman, 96-In. Hot Mill, Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

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"Trends in Ingot Buggy Design," by H. G. Frostick, General Supervisor, Design Engineering, United States Steel Corp., South Works, Chicago, Ill.

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"Safeguarding Steel Production," by R. M. L. Russell, Assistant Chief Engineer, Factory Insurance Assn., Hartford, Conn.

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"Treatment of Liquid Wastes from Steel Plants," by Ross Nebolsine, President, Hydrotechnic Corp., New York, N. Y.

"Summary of Operating Results with Oxygen," by J. H. Strassburger, Assistant Vice President, Weirton Steel Co., Div. of National Steel Corp., Weirton, W. Va.

"Benefits of Purchased Oxygen to the Indiana Harbor Works of the Inland Steel Company," by N. R. Kirkdoffer, Superintendent, Power, Steam and Combustion Depts., Inland Steel Co., East Chicago, Ind.

"Economics of Generated Versus Purchased Oxygen for Steel Plant Use," by R. A. Lambert, Superintendent, Steam Efficiency and Combustion Dept., Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"Oxygen Plant Cycles Tailored to the Requirements of Iron and Steel Producers," by Clarence J. Schilling, Vice President and Chief Engineer, Air Products, Inc., Allentown, Pa.

"Operation and Maintenance of a 100-Ton, Double-Cycle, Gaseous Oxygen Plant," by G. T. Wright, Mechanical Superintendent, Dominion Foundries and Steel, Ltd., Hamilton, Ontario, Canada

"Recent Hot Strip Mill Roughing Trains," by J. H. Greiner, Electrical Application Dept., Industrial Equipment Div., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

"Practical Aspects of Power Layouts for Steel Mills," by A. J. Mosso, Vice President, Auburn & Associates, Inc., Pittsburgh, Pa.

"Constant Horsepower Computer—Permitting the Use of Slip Couplings for Winder Drives," by P. R. Gravenstreter, Electrical Engineer, The Clark Controller Co., Cleveland, Ohio

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Make your room reservation directly to the Penn-Sheraton Hotel, giving time of arrival, length of stay and type of accommodations desired. Reservations should state that they are for the AISE Convention. If the hotel is unable to take care of you, it will forward your request to the Pittsburgh Convention Bureau, who will place you elsewhere. Penn-Sheraton rates are: single room, $8.00–$11.00; double room, $12.50–$14.00; twin room, $13.50–$19.50.

View shows new Mellon Square in downtown Pittsburgh. At right is Hotel Penn-Sheraton

By J. L. Garrison, Application Engineer, Heat Treat & Metalworking Div., Leeds & Northrup Co., Philadelphia, Pa.

Infrared Analyzers Monitor Furnace Atmospheres

▲ PRECISE measurement and control of heat-treating furnace atmospheres on a production basis improves the annealing, hardening and carburizing of steel products. Lower operating costs, simplified machining and an increase in usable product are among the benefits that automatic atmosphere monitoring with infrared analyzers brings to the steel and metalworking industries.

Carbon level of furnace atmosphere can be predicted by measuring either CO, CO_2 or CH_4 (methane), as long as the composition of the gas supplied to the atmosphere generator is constant. Where production practice calls for periodic changes in air-gas ratios, continuous CO or CO_2 monitoring permits rapid and accurate adjustments of gas composition to control generator output. With a continuous record, the operator can maintain a constant output at all times.

There are, however, many instances where the composition of the gas supply will vary, due to instability or changes of local supply during peak loads. In such cases, generator output monitoring is particularly valuable.

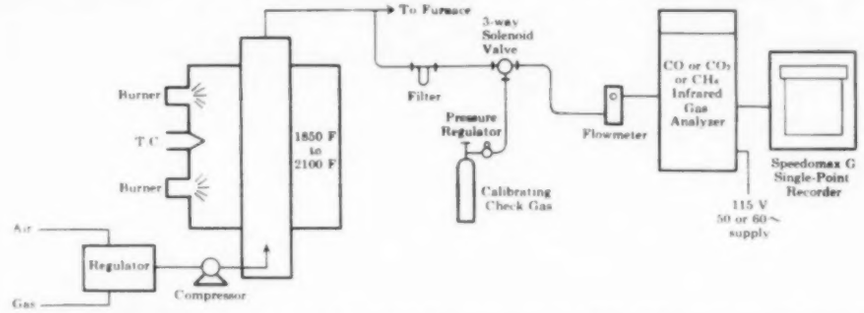


Figure 1 — Either CO, CO_2, or CH_4 can be measured with this system. Filtered gas passes through a flowmeter before entering the analyzer, so that the proper rate of flow can be maintained. A three-way solenoid valve admits gas of known composition to the analyzer, for a monthly, three-minute checkup of calibration.

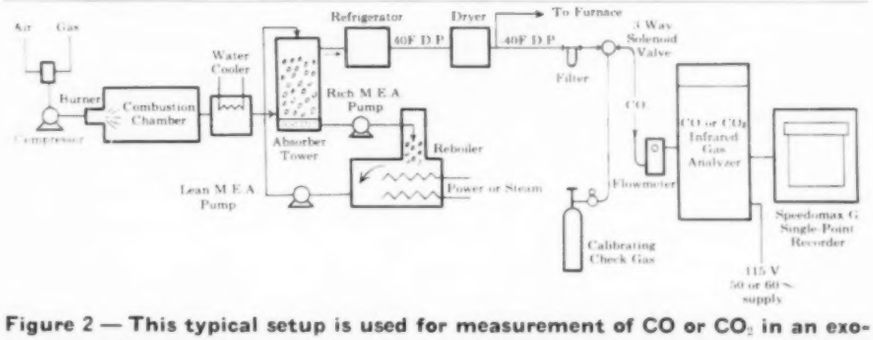
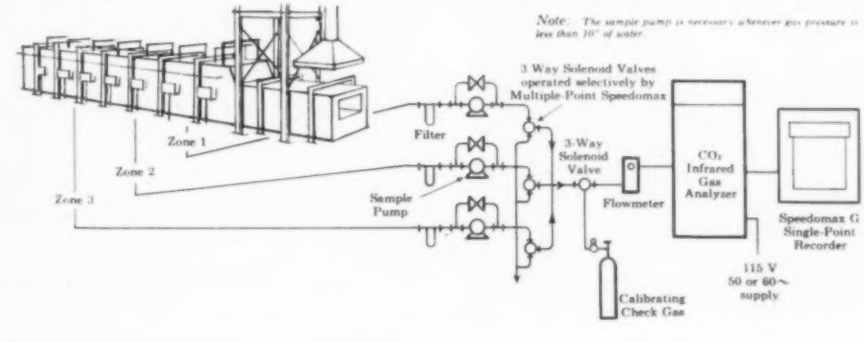


Figure 2 — This typical setup is used for measurement of CO or CO_2 in an exothermic atmosphere, where the gas is scrubbed to provide a high N_2 composition. Sample is taken after refrigeration and drying. In cases where gas is not scrubbed, the measurement is made directly after combustion and cooling.

Figure 3 — Measurements of CO, CO_2 and CH_4 can be made from several zones of a multi-zone furnace. In this system, samples are successively taken from each of three zones at 30-sec intervals. A selector switch in the recorder can be set to continuously monitor any given zone. Sample pumps are used wherever gas pressure is less than ten inches of water.


Note: The sample pump is necessary wherever gas pressure is less than 10" of water.
3 Way Solenoid Valves operated selectively by Multiple-Point Speedomax
Zone 1
Zone 2
Zone 3
Filter
3-Way Solenoid Valve
Sample Pump
Flowmeter
CO2 Infrared Gas Analyzer
Speedomax G Single-Point Recorder
115 V 50 or 60 ~ supply
Calibrating Check Gas

EXOTHERMIC GENERATORS

The simplicity of the basic generating equipment and a wide range of available variations make this atmosphere suitable for the greatest number of installations. Exothermic gas is produced by burning a gaseous fuel in combination with air, with a controlled gas-air ratio. Relatively inexpensive fuels are used, such as propane, butane, natural gas, or city gas. The atmosphere produced is essentially a combination of hydrogen, carbon monoxide, nitrogen, carbon dioxide, methane and water vapor. Generally, the CO_2 and H_2O are removed to supply a high-nitrogen reducing atmosphere, containing a controlled amount of CO and H_2. An atmosphere of this type will prevent oxidation in many products. The analysis of gas required, and hence the gas-air ratio, is dictated by the metallurgy of the product and the selected heat treatment.

Water vapor is removed by passing the gas through a refrigerated chamber which condenses out enough water to lower the dew-point to about 40 F. Adsorption by

a desiccant-filled drying unit removes additional moisture so that the dewpoint of the final furnace atmosphere is about −40 F.

Carbon dioxide is removed by an amine solution, (monoethanolamine), in an absorption tower. Known as scrubbers, these CO_2 removal units are normally designed for a certain rated capacity—overloading prevents full CO_2 removal. If this should happen, the increased CO_2 content of the atmosphere would cause excessive decarburization of the work, and possible oxidation.

Scrubber performance can be checked by a CO_2 analyzer, mounted in the scrubber exit line. To check the performance of the entire generating system, a CO analyzer can be employed.

ENDOTHERMIC ATMOSPHERES

Endothermic gas is made by reacting a gas-air mixture at a high temperature. The principal difference between this and exothermic atmospheric production is that heat must be added to the endothermic generator in order for the reaction to take place, while the exothermic reaction requires no additional heat.

Endothermic generators are designed and operated to obtain high H_2 and CO and low CO_2, CH_4 and H_2O vapor contents. Infrared analyzers are commonly used to monitor either CO_2, CH_4, or both, in order to obtain quality control of endothermic atmospheres.

ATMOSPHERE MONITORING APPLIED

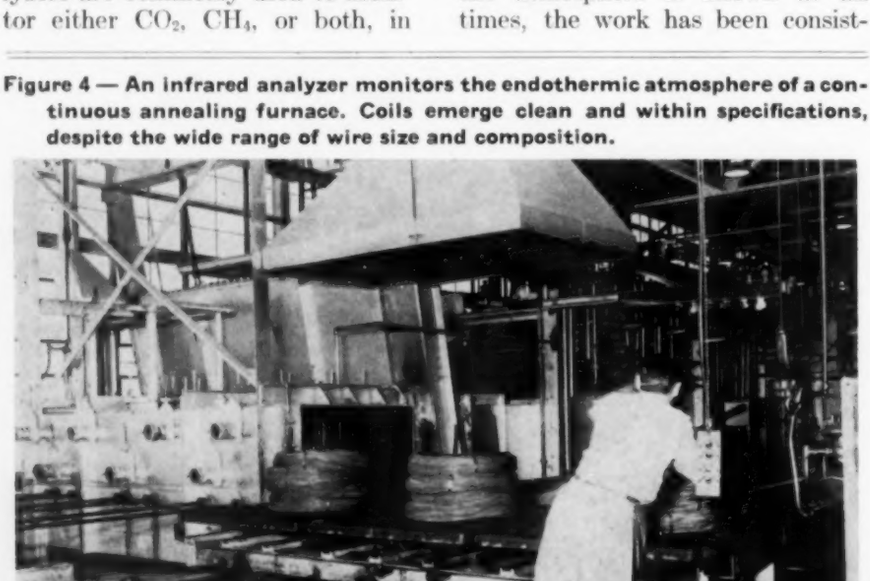
At a midwestern wire mill automatic monitoring has improved product consistency and has reduced rejects. The plant manufactures wire in all sizes, up to ¾ in. diam, in at least a dozen grades of steel, from SAE 1010 to 52100. Coils for heat treating range from 10 to 36 in. inside diam. Because of this variation in size and product composition, the makeup of the protective atmosphere is critical.

They use a continuous annealing furnace, the first one of its kind. Thirteen fans provide uniform forced air circulation through the 62-ft heating zone and the 31-ft cooling zones. Protective atmosphere for both zones is supplied by an endothermic generator, which produces a reducing atmosphere that is low in water vapor and CO_2. This prevents oxidation and decarburizing of the wire.

To monitor this atmosphere, a Leeds & Northrup infrared analyzer with a range of 0 to 3 per cent CO_2 was selected. Analyzer cell assembly and calibrating equipment are mounted adjacent to the furnace—the Speedomax recorder is in a central control room.

Because the exact composition of the atmosphere is known at all times, the work has been consistently of higher quality—coils are clean and always within specifications, despite the wide range of wire sizes and materials.

Figure 4 — An infrared analyzer monitors the endothermic atmosphere of a continuous annealing furnace. Coils emerge clean and within specifications, despite the wide range of wire size and composition.



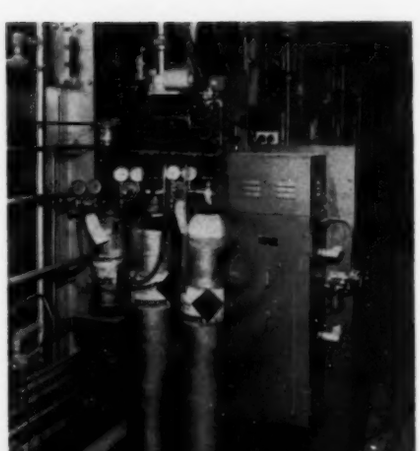


Figure 5 — Analyzer cell assembly and calibrating equipment are mounted beside the heating zone of the furnace.

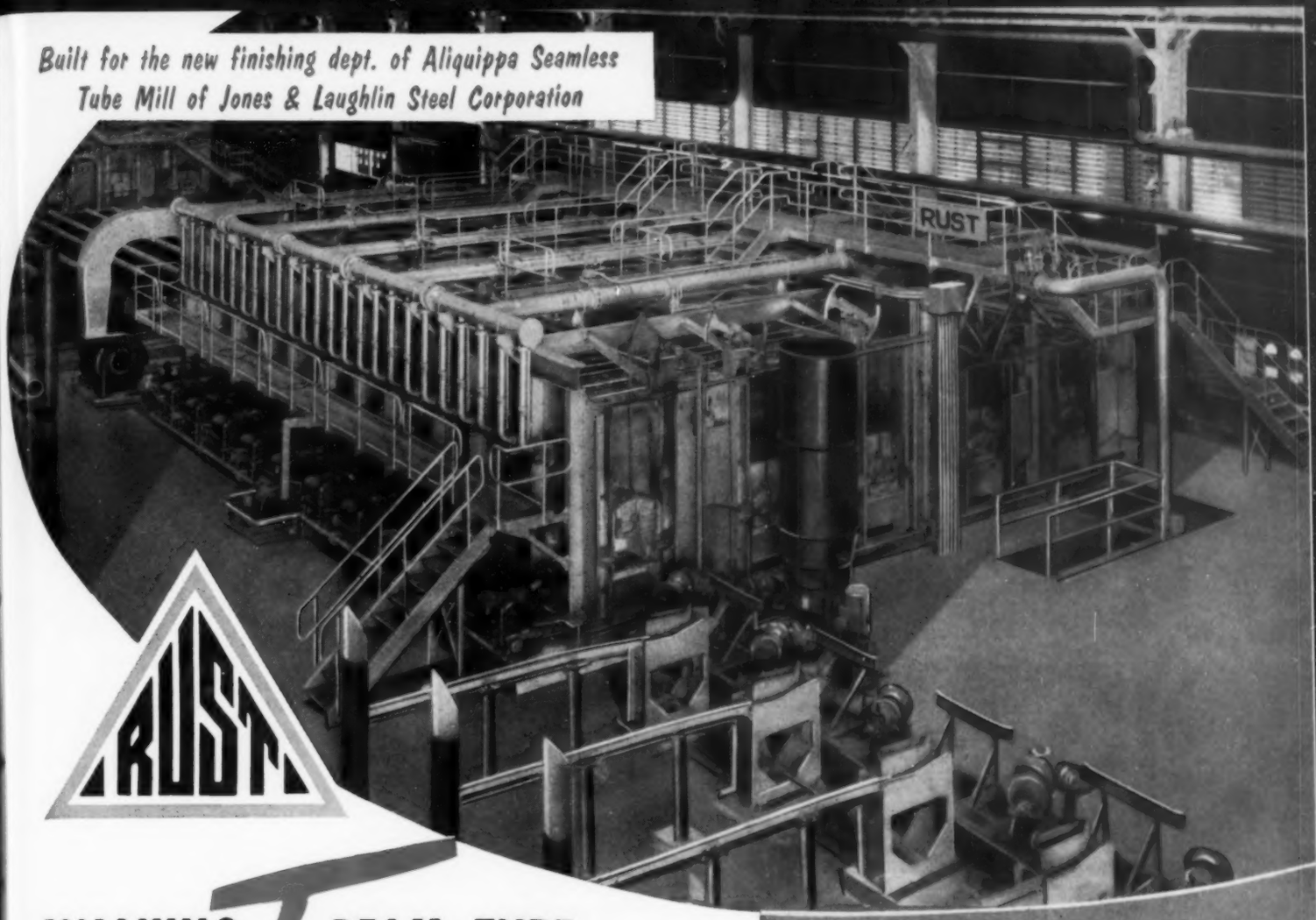
HOW THE ANALYZER WORKS

The industrial infrared analyzer comprises two basic components: an analyzer cell, which is usually mounted at or near the furnace; and an electronic recorder, mounted either at the furnace or in a central control room. Measurement is based on the fact that different gas compounds in a mixture absorb radiation from different parts of the infrared spectrum. Thus each compound has its own "fingerprint" in relation to infrared energy absorption.

Infrared radiation from a constant source is passed through a sample of the atmosphere to be measured and, at the same time, through a known reference gas. The radiation difference is detected by a thermopile, which incorporates differentially connected chromel-constantan thermocouples, with immunity to stray electrical pick-up or mechanical vibration. Changes in thermopile emf output are measured and recorded by the electronic recorder, which is calibrated directly in per cent of the gas compound in the sample cell.

Recorders are available to plot the percentage of a single gas sample or several samples of the same constituent on one chart. Single-point recorders can have either round or strip charts. Multiple-point recorder use a strip chart exclusively.

Built for the new finishing dept. of Aliquippa Seamless Tube Mill of Jones & Laughlin Steel Corporation



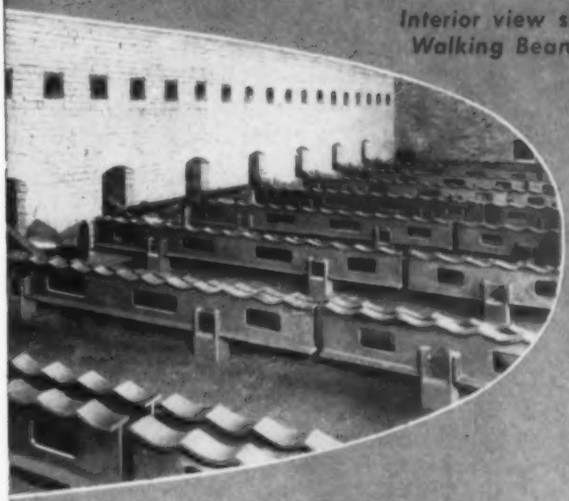
RUST

WALKING BEAM TYPE HEAT TREATING *Furnaces*

For heat treating their seamless tubing, the Jones & Laughlin Steel Corporation chose two specially-designed Rust furnaces as shown above. These walking beam type furnaces were designed and constructed by Rust in record breaking time—and they are helping the new "J & L" Seamless Tube Finishing Department to break records in producing, conditioning, and finishing high tensile strength seamless tubes.

Be sure to consult Rust on any problem of tube and pipe annealing, heat treating, and processing. Rust also designs and builds other type furnaces to meet every metallurgical heating need.

Interior view showing Walking Beam Rails



FIRST *installation of this type for Normalizing, Quenching and Drawing of Seamless Tubes*

THE WHOLE JOB IS ONE JOB WITH A "RUST PACKAGE CONTRACT"

One contract covers everything, from original idea to start-up. One responsibility for design, manufacture, erection and initial operation. One overhead and profit (with substantial savings to you) on all phases of the work, including wiring and piping.

Rust Furnace Company

Pioneers in Furnace Design

Rust Building • Pittsburgh, Pa.

New Oxygen Plant Goes into Production at U. S. Steel's Duquesne Plant

▲ A new gaseous oxygen producing unit is now in regular production at the U. S. Steel Corp.'s plant at Duquesne, Pa. Owned, built and operated by Linde Co., a division of Union Carbide Corp., the oxygen production unit (rated over 500 tons per day) is wholly in the service of the Duquesne works.

The new unit delivers oxygen for these operations: (1) 430,000 cfhr of 95 per cent pure (low purity) oxygen into pipelines directly to two ferromanganese blast furnaces (normal daily production of 700 tons of ferromanganese will be boosted 25 per cent); (2) an initial delivery rate of 42,000 cfhr 99.5 per cent pure (high purity) oxygen per hour to the pipelines servicing electric furnaces, scarfing machines and other steel mill operations; and (3) a stream of liquid oxygen for standby storage.

Altogether, this one unit produces oxygen at an initial delivery rate of over 500 tons per day.

To assure a continuous supply of low purity oxygen when necessary repair and maintenance shuts down the unit, a 15-hr reserve (at least 6,500,000 cu ft) will be stored in a 10,000,000-cu ft tank. The reserve will be built up by the unit's own production stream of liquid oxygen. However, the high purity supply is not limited by either production or storage, since Linde can provide additional high purity oxygen by tank car or tank truck shipments from its system of liquid oxygen producing plants.

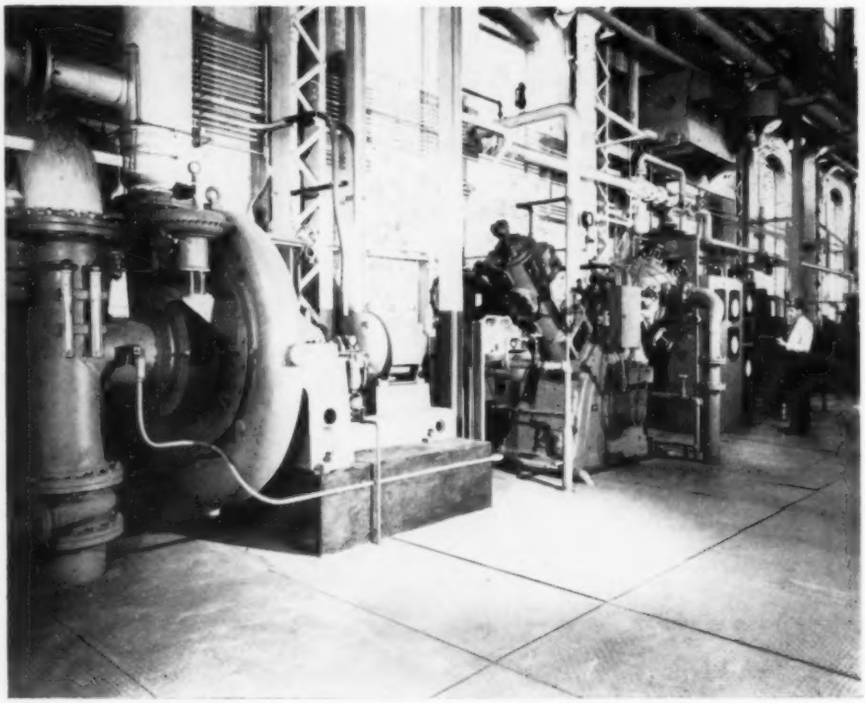
Linde's on-site plants already operating or being built are adding significantly to the nation's oxygen production for steel and chemical manufacturers. These units range in capacity from 10 tons to thousands of tons per day. This installation program began shortly after World War II with the erection of a few units and within the last year or two has been greatly accelerated.

The investment burden in oxygen production units is considerable, but Linde's system relieves industry of the necessity of freezing capital funds in such auxiliary plants. Linde spends its own money to build oxygen plants, retains ownership of them (thus assuming the risks of obsolescence, which are high in this dynamic industry), carries the responsibility of maintenance and efficiency of performance, and contracts to sell oxygen to the mill as it is needed.

Two factors inherent in mill practice and oxygen production require assurance of resources of supply over and above the maximum economical production of any unit:

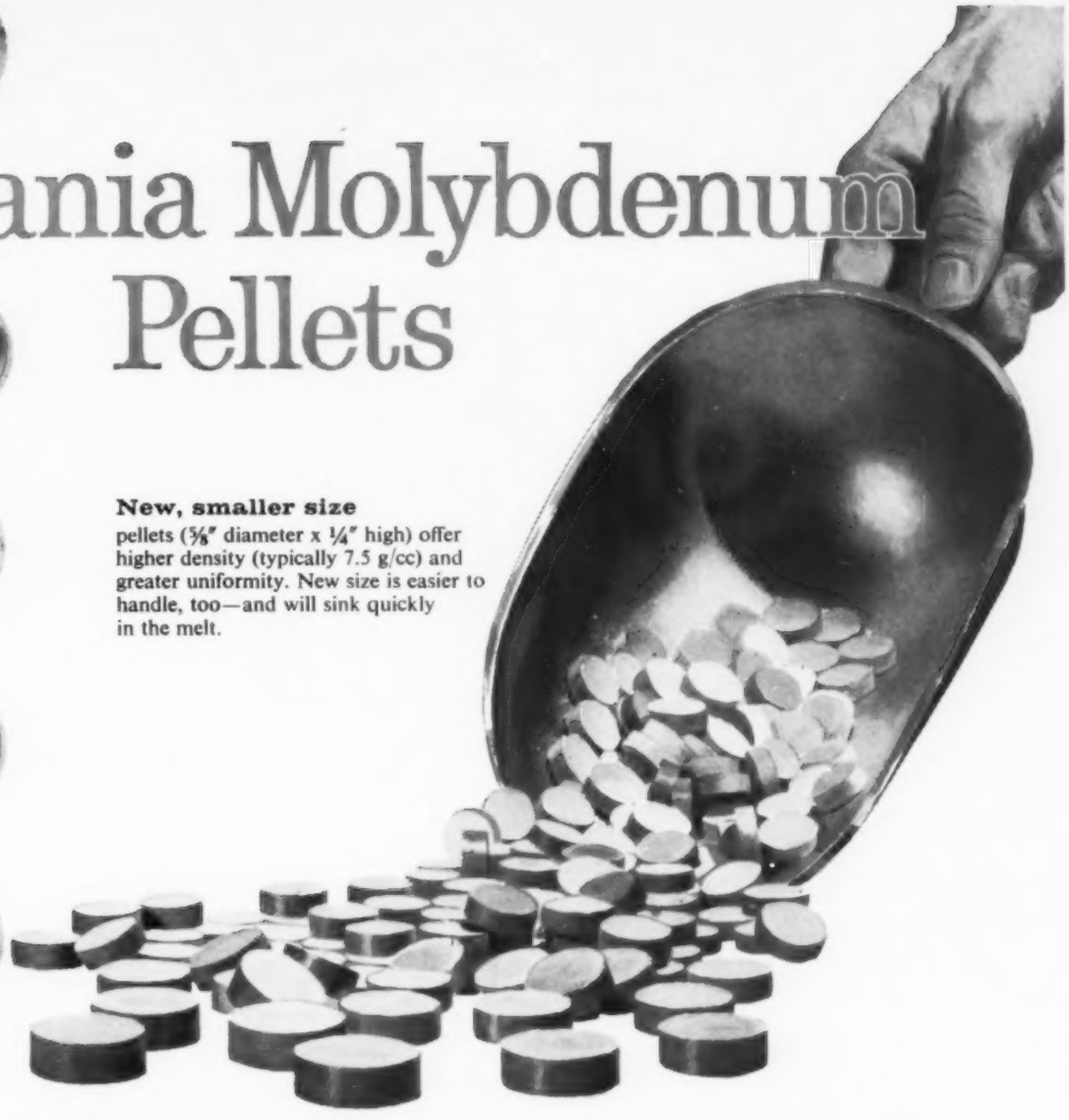
1. Metallurgical oxygen con-

Figure 1 — Low-purity gaseous oxygen is compressed to pipeline pressure by the single-stage centrifugal blower at left. The base-load compressor (right) performs the initial compression of the high-purity oxygen output of this plant.



Sylvania Molybdenum Pellets

New, smaller size
pellets (⅜" diameter x ¼" high) offer higher density (typically 7.5 g/cc) and greater uniformity. New size is easier to handle, too—and will sink quickly in the melt.



—the new form manufactured to specified purity and composition

Sylvania Molybdenum Pellets are designed and manufactured specifically for use in vacuum melting. They provide a readily available source of the best purity molybdenum (typical 99.85%) available on the market. Detrimental impurities are at an extremely low level. This consistent high purity simplifies the calculation of additions to each melt as the usual variations of purity and gas content are eliminated.

By maintaining a high density, the gas content of the pellets is kept well below that acceptable for vacuum melting. In addition, the compact uniform size of the pellets facilitates weighing and charging to the melt.

When you use Sylvania Molybdenum Pellets, you benefit in other ways, too. Their continuous availability means you can plan your production schedules on a long-range basis. Further, their pricing stability permits you to price your own product without having to worry about fluctuating raw materials costs.

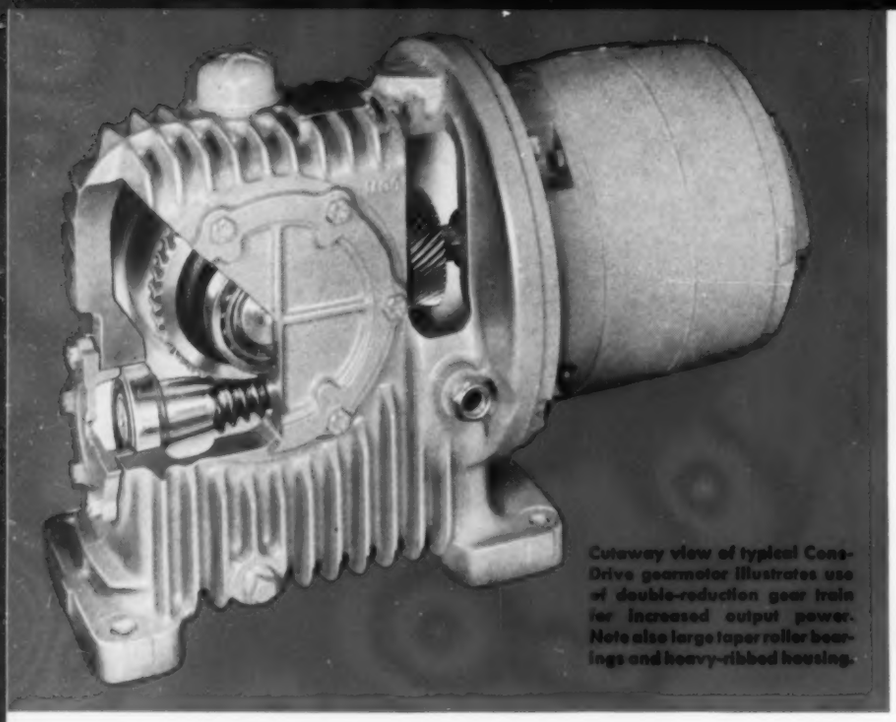
Call your Sylvania representative or write for details.

SYLVANIA ELECTRIC PRODUCTS INC.
Tungsten and Chemical Division, Towanda, Pa.

TUNGSTEN • MOLYBDENUM • CHEMICALS • PHOSPHORS • SEMICONDUCTORS

SYLVANIA

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY



Cutaway view of typical Cone-Drive gearmotor illustrates use of double-reduction gear train for increased output power. Note also large taper roller bearings and heavy-ribbed housing.

Announcing a POWERFUL NEW DRIVE *by* CONE-DRIVE GEARS

Here are the "why's" for this new gearmotor

Why a right-angle gearmotor?
You save space! By tucking the entire unit in close to the driven shaft, there's nothing to stick out in crowded aisles. It's out of the way.

Why a double-reduction design?
More power! Combining a helical primary with a Cone-Drive double-enveloping worm gear secondary gives you an extremely high load-carrying capacity. Output torque ratings are much higher than those of single reduction gearmotors. Overall ratios are greater, too.

Why double-enveloping worm gears?
More power! Cone-Drive double-enveloping worm gears have proven that they provide maximum load carrying capacity on extremely small center distances. This means, in many cases, that they will handle two to four times the load of cylindrical worm gears of the same size. An added plus is high resistance to shock loads, long operating life and minimum maintenance requirements.

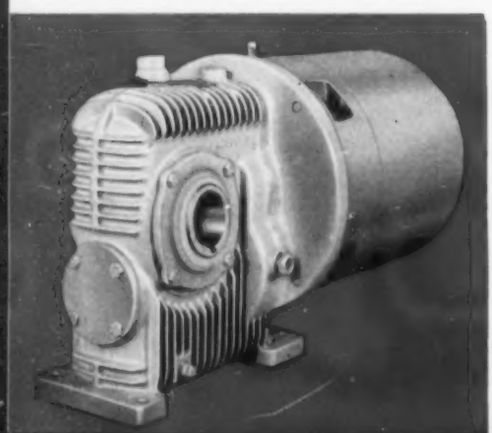
Why different types of mountings?
Flexibility! You can select Cone-Drive gearmotors with extended shaft or for shaft mounting. Both are standard. Shaft mounting often permits "hanging" the driven load on the gearmotor to eliminate pillow blocks, bearings, torque arms, shafts, pulleys, bed plates, etc. Both types may be floor, wall or ceiling mounted as desired.

Why 27 standard output speeds?
Standardization! Standard reductions range from 3.3:1 to 240:1. Speeds at 1750 rpm input range from 525 rpm to 7.3 rpm output speed. Any variation in input speed will naturally provide another complete set of 27 output speeds. Any standard type NEMA D-flange motor may be used. Other reductions may be obtained on special order at additional cost.

Why ratings to only 25 horsepower?
Demand! Extensive market research by Cone-Drive Gears reveals that this is the most popular power range in the application of gearmotors by industry. Currently we are building models in capacities from 1 to 25 horsepower. However the compact size and high capacity of the Cone-Drive gearmotor will extend this range in the future. Space requirements for higher capacities will be substantially reduced with our new design.

Why a Cone-Drive gearmotor?
Dependability! For over 20 years Cone-Drive Gears has been building double-enveloping worm gears and speed reducers. Design and manufacturing techniques have been constantly improved so that today these unique gears provide, size for size, the highest load-carrying capacity of any right angle worm gearing. Now, you can take advantage of this outstanding gearing combined into an integral package that eliminates pulleys, sheaves, belts, chain, bearings and all the trouble that goes with separate reducer and motor combinations. You'll get increased efficiency at lower cost by specifying standard Cone-Drive gearmotors.

Bulletin #57 contains complete details. Ask for it today.



◀ Here's the finest shaft mounted gearmotor on the market today. It is available in all sizes with ratings identical to other Cone-Drive gearmotors.

CONE-DRIVE GEARS
Division, Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNICHOLS ROAD • DETROIT 12, MICHIGAN

sumption is peculiarly subject to short periods of extremely high demand.

2. Oxygen producing units produce more or less steady quantities of the gas.

Linde overcomes these mutually incompatible situations by backing up on-site production with its nationwide Driox oxygen system of liquid oxygen production and distribution. The Driox oxygen system is always available to satisfy mill demand, even during unavoidable downtime for repair and maintenance of any oxygen producing unit.

That Linde's system is equal to almost any demand put upon it was proved at the Duquesne works during the winter of 1954–55. Duquesne's management had decided on a three-month full-scale test of the use of oxygen for air enrichment of the ferromanganese blast furnaces. The Duquesne experiment called for up to 300,000 cfhr of oxygen, over and above the normal requirements of the mill. During the test period this demand was readily satisfied with Driox oxygen. Neither Linde nor Duquesne had to make significant capital investments for the test. Tank cars of liquid oxygen emptied their loads into pipelines which passed through converters and thence directly into the blast furnaces.

Thus, while the Duquesne unit is expected to give years of trouble-free service, the Driox system will provide a stand-by source in the event of unforseeable accident or unprecedented demand.

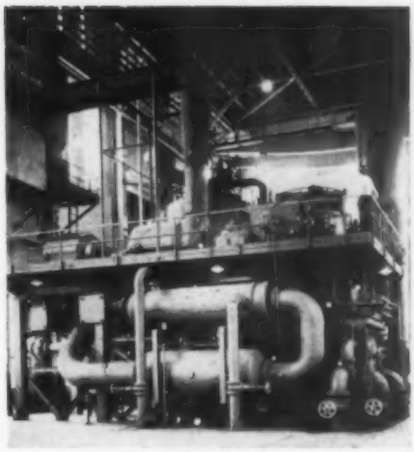


Figure 2 — A 42,000-cfm, 74.5-psig centrifugal air compressor, driven by a steam turbine powers the oxygen unit at Duquesne. Air is brought in through the filter room at upper left, and passes through the duct into the first stages of compression.

Small Size— Better Efficiency Feature New Dust Collector

▲ A new tool for dust collecting chores was demonstrated recently by Joy Manufacturing Co., Pittsburgh, Pa. The unit is described as one-tenth to one-twentieth the size of comparable equipment. Called the Joy Microdyne dust collector, the new unit is a wet, inertial type which has an efficiency greater than any comparable wet type collector. Test figures show that the unit has an efficiency of 99-plus per cent in collecting dust particles of five microns or greater.

Prototype models have already been tested under actual working conditions at the Brackenridge, Pa. plant of Allegheny Ludlum Steel Corp.; a Butte, Mont., mine of The Anaconda Co.; an Ishpeming, Mich., iron mine of Cleveland Cliffs Mining Co.; a phosphate processing plant in Florida; and several other locations in the United States.

The application at Allegheny Ludlum Steel Corp.'s Brackenridge plant is for a new grinding operation recently set up to eliminate surface imperfections on slabs of stainless steel. Designated Number 10 Grinding Department, this operation is using four of the new Joy Microdyne dust collectors, at 48,000 cfm each, to bring about effective dust control.

At Brackenridge, the company's new grinding department employs seven new grinders to work over the surfaces of stainless steel slabs. Each grinder faces a booth into which the sparks and fine dust from the slab surfaces are sprayed. All so-called floating dust is pulled into a hood and connecting duct work immediately above each booth.

In April of 1957, as the grinding operation was nearing completion, Allegheny Ludlum installed four prototype Joy microdynes, the largest units available, directly into the duct work over the grinding operation.

One of the major questions in the

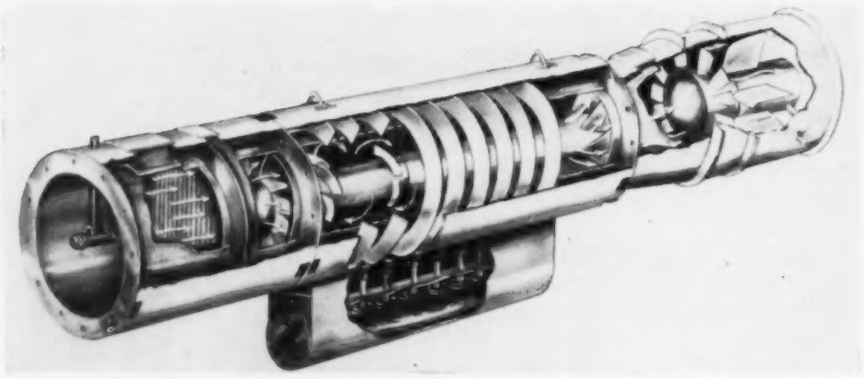


Figure 1 — Contaminated air enters the dust collector through the unit's mixing section which contains a water spray and impingement element. The central part of the unit is a water elimination section which is an axial type cyclone with turning and straightening vanes. The third section is a transition area, containing the axial flow fan.

selection of a dust collector was how to achieve the necessary dust control without installing a unit for each grinder. With the Joy Microdyne, it is possible to move a tremendous volume of air at moderate cost. With four units handling the dust from seven grinders, savings in space as well as installation expenses were attained. Slurry is removed with only one settling tank located at the end of the grinding plant, into which material from all four Joy Microdynes is pumped. Most units require individual boxes to receive slurry which results in added maintenance costs.

The equipment is made of type 316 stainless steel which is able to withstand the corrosive and erosive action of the grinding wheel abrasive particles and high alloy steel dust mixed with water.

The new dust collector is Joy's first entry in an industry which now has some 20 leading equipment-producing firms and does an annual volume conservatively estimated at $300,000,000. These manufacturers are trying to solve air pollution problems which are currently costing the United States more than $2,000,000,000 each year.

The new dust collector is unique in that it embodies all of the fundamental principles of the Greenberg-Smith impinger, long used as the standard dust measuring instrument by the United States Public Health Service.

Real impingement only occurs when dust and its carrying air impinge at high speed (4500 to 6000 lineal fpm) against a film of water. This happens in the mixer section of the microdyne.

The microdyne is a cylindrical device having two essential parts; a mixer section and an eliminator section. The dust-laden air or gas enters the unit at its mixer section. Here the impingement takes place. Each dust particle is enveloped in water as it passes through a fine spray.

The air and entrained, water-enveloped dust pass through turning vanes as they enter the eliminator section. These vanes impart a helical motion which causes a centrifugal force. This force dynamically separates the entrained particles from the air. The dust-laden water is captured at the periphery of the eliminator section in blind louvres which are connected to a disposal sump at the bottom of the unit.

The cleaned air passes out of the eliminator section through straightening vanes which recover energy of rotation thus reducing over-all draft loss.

If sufficient pressure to drive the gases is not available ahead of the microdyne, a vaneaxial fan may be attached at the rear of the unit.

The dust collector can be mounted in existing duct work at the point of use. Space and installation economies to be realized are considerable.

The variety of applications for the dust collector has not yet been fully explored.

Figure 2 — Allegheny Ludlum Steel Corp's No. 10 grinding department at Brackenridge, Pa., employs seven grinders to remove surface imperfections from stainless steel slabs.

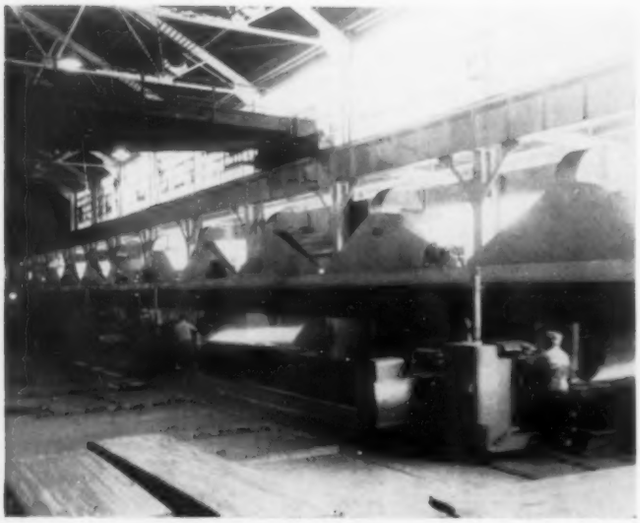
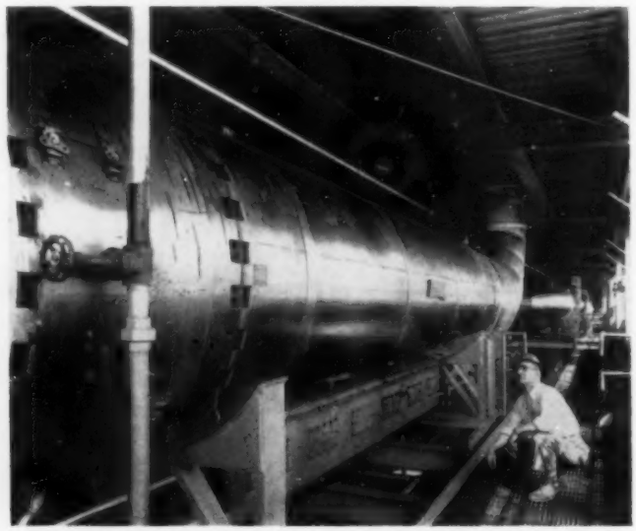


Figure 3 — Collecting dust from a bank of seven grinders are four microdynes, each with a capacity of 48,000 cfm. These units are almost maintenance-free due to their stainless steel construction.



He'll settle for perfection, nothing less

While a keyway is being milled in the neck of this hardened steel roll, the Bethlehem machinist is taking a final reading on the bearing diameter. Sure, it's been checked before, but he wants to be absolutely certain.

Despite the expert machining that is a part of every Bethlehem roll, inspections are numerous and thorough. The whole idea is to shoot for perfection.

The roll shown above will be used in the making of steel sheets and blackplate. It weighs in the neighborhood of 3½ tons; has a body length of 56 in. and a body diameter slightly over 21 in. The unit is typical of many that Bethlehem produces each year. But Bethlehem shops often make rolls weighing several times as much—as well as some so small that they can be lifted by hand. And all of them, large and small alike, receive the same careful workmanship, the same careful inspection.

Whatever your requirements, Bethlehem can meet them in full. Call us whenever you need rolls for cold-rolling steel sheets and strip . . . running down and finishing steps on copper and brass sheets . . . hot- and cold-rolling aluminum sheets . . . cold-rolling aluminum foil.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Dravo Opens New Research Laboratory

▲ DRAVO Corp. recently formally dedicated its new half-million-dollar research center on Neville Island, adjacent to the company's main plant. The T-shaped structure, located on a two-acre plot between the Ohio River back channel and Neville Road, houses centralized facilities for Dravo's research and development department, which was established in 1952 and moved into its new quarters early this year.

All research at the center is directly related to Dravo's diversified product lines and performs five major functions. These are: (1) development of new products. (2) improvement in design of existing products, (3) improvement in fabrication or construction processes, (4) development of new uses for existing products, and (5) quality control.

The well-equipped, modern laboratories include metallurgical, chemical, physical testing, heater, sintering and pelletizing, concrete and marine research facilities. All laboratories are located on the first floor of the building, with the exception of the concrete laboratory, which is located in the basement.

Work in the metallurgical laboratory includes detailed studies of strength, hardness and microstructure of metals, as well as their resistance to temperature changes or stress. In the chemical laboratory, tests are run on lubricating and fuel oils, river water acidity and its corrosive effects on towboats and barges, chemical analyses of materials used in construction, and durability of paints in underwater and atmospheric exposures.

Closely related to the metallurgical laboratory in its work with metals is the physical testing laboratory, which also is used for tests on the strength of concrete and other materials. A major project conducted in this laboratory is a series of tests on the "growth" or enlargement of cast iron under repeated heating and cooling. This has particular application for Dravo because of the large number of cast iron grate bars used in its sintering machines.

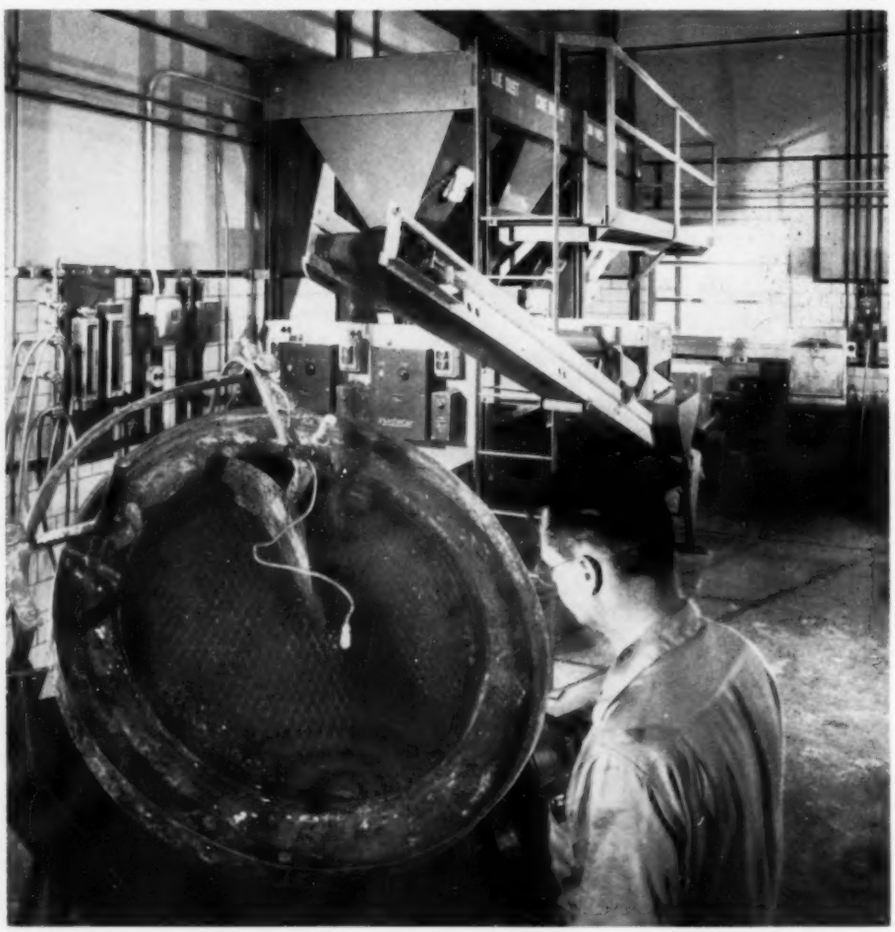
Concrete laboratory tests are made on the gradation and soundness of aggregates, studies of cement characteristics and trial mixes. Currently under study is the possible use of other materials, such as fly ash, as a partial replacement for cement in the mixing of concrete.

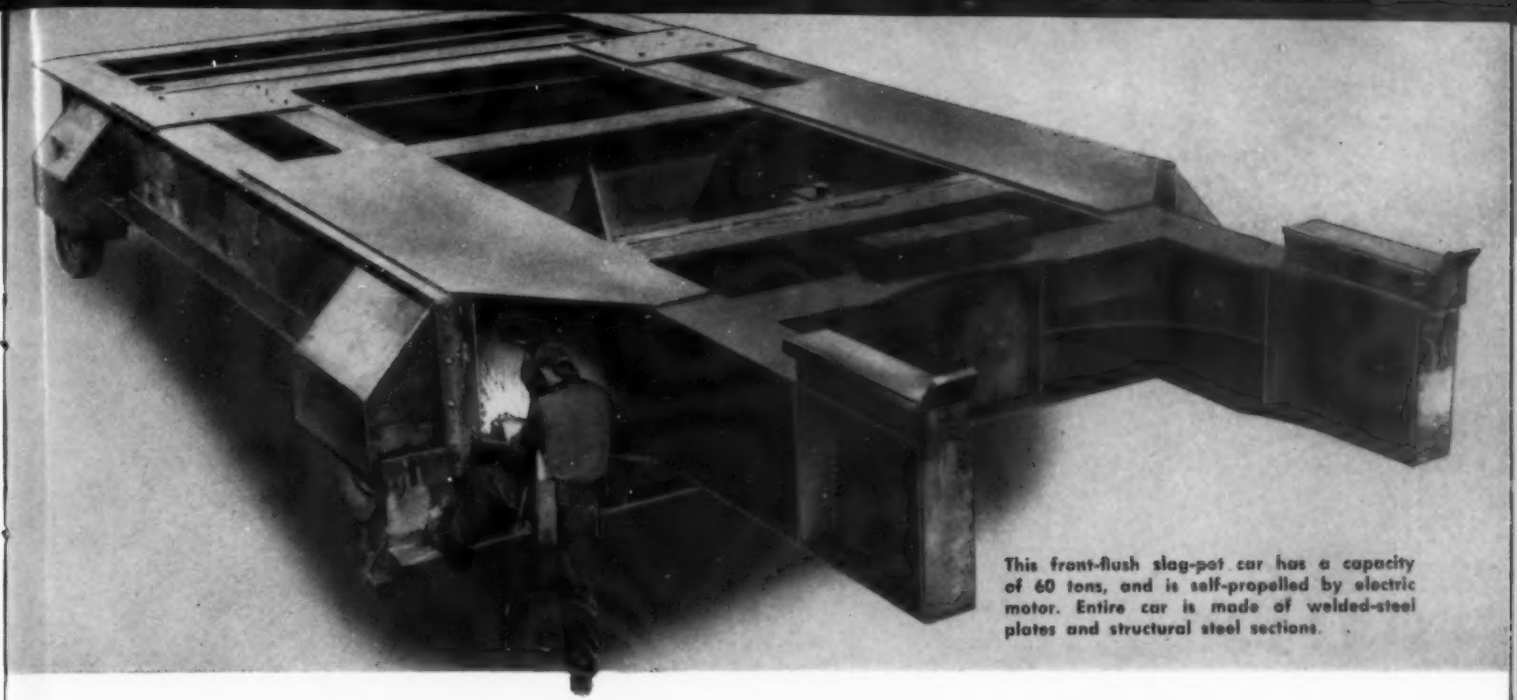
Dravo's new Counterflo industrial heater is the result of three years of research in the heater laboratory. Here new models of heaters are developed and subjected to Underwriters' Laboratory and American Gas Association tests before they are placed in production.

In the sintering and pelletizing laboratory, small-size sintering and pelletizing machines transform iron ore dust and fines into seed pellets which in turn are used in making sintered "clinker" suitable for feeding to blast furnaces. Tests also have been run on many other fine and powdered materials to determine if they can be pelletized. One such test converted fine powder, left over in the manufacture of a breakfast cereal, into pellets suitable for chicken feed.

The new center will supply Dravo with applied product research in the fields of inland waterways equipment, heavy construction, industrial heating and air conditioning, sintering and pelletizing, bulk materials handling, chemical process equipment, incineration and many others.

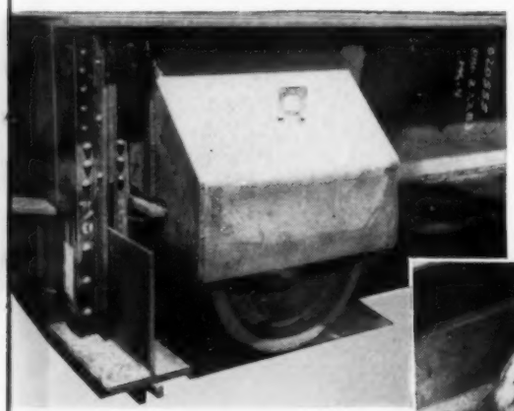
Figure 1 — Model sintering and pelletizing machinery is helpful in determining the size of machine a customer needs for his production. Model machinery also is used for tests on various types of material which may be pelletized. The sintering laboratory is one of seven major facilities in the new building.



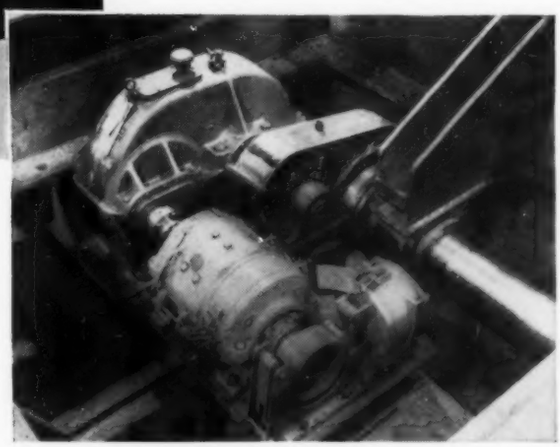


This front-flush slag-pot car has a capacity of 60 tons, and is self-propelled by electric motor. Entire car is made of welded-steel plates and structural steel sections.

FRONT-FLUSH CARS
USS-DESIGNED
to your specifications



Note solid corner construction and splash guard over wheel.



Close-up photo of electric motor and gear-drive unit.

WHEN YOU NEED industrial cars, get in touch with United States Steel. Our engineers can design the kind of cars you want. What's more, they will be custom-made to your exact specifications.

A good example of a USS-Designed Car is illustrated here. It's a front-flush slag-pot car with a capacity of 60 tons. The slag pot is carried between the trunnions on the front. For balance, the other end of the car carries a 43-ton counterweight.

This car is self-propelled by an electric motor, and has suitable gear drive for use in steelmaking operations. Car is made of welded-steel plates and makes extensive use of wide-flange structural sections. It is designed for use on a 16′3⅝″-gage track—much wider than standard gage.

Our engineers will be pleased to call at your convenience to discuss front-flush cars or other types of industrial cars. Meanwhile, mail in the coupon and we will send you a free copy of our 32-page illustrated booklet—"USS Custom Designed Cars."

USS INDUSTRIAL CARS

USS

UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

United States Steel Corporation
525 William Penn Place, Room 2801
Pittsburgh 30, Pennsylvania

Please send me a free copy of your 32-page booklet, "USS Custom Designed Cars."

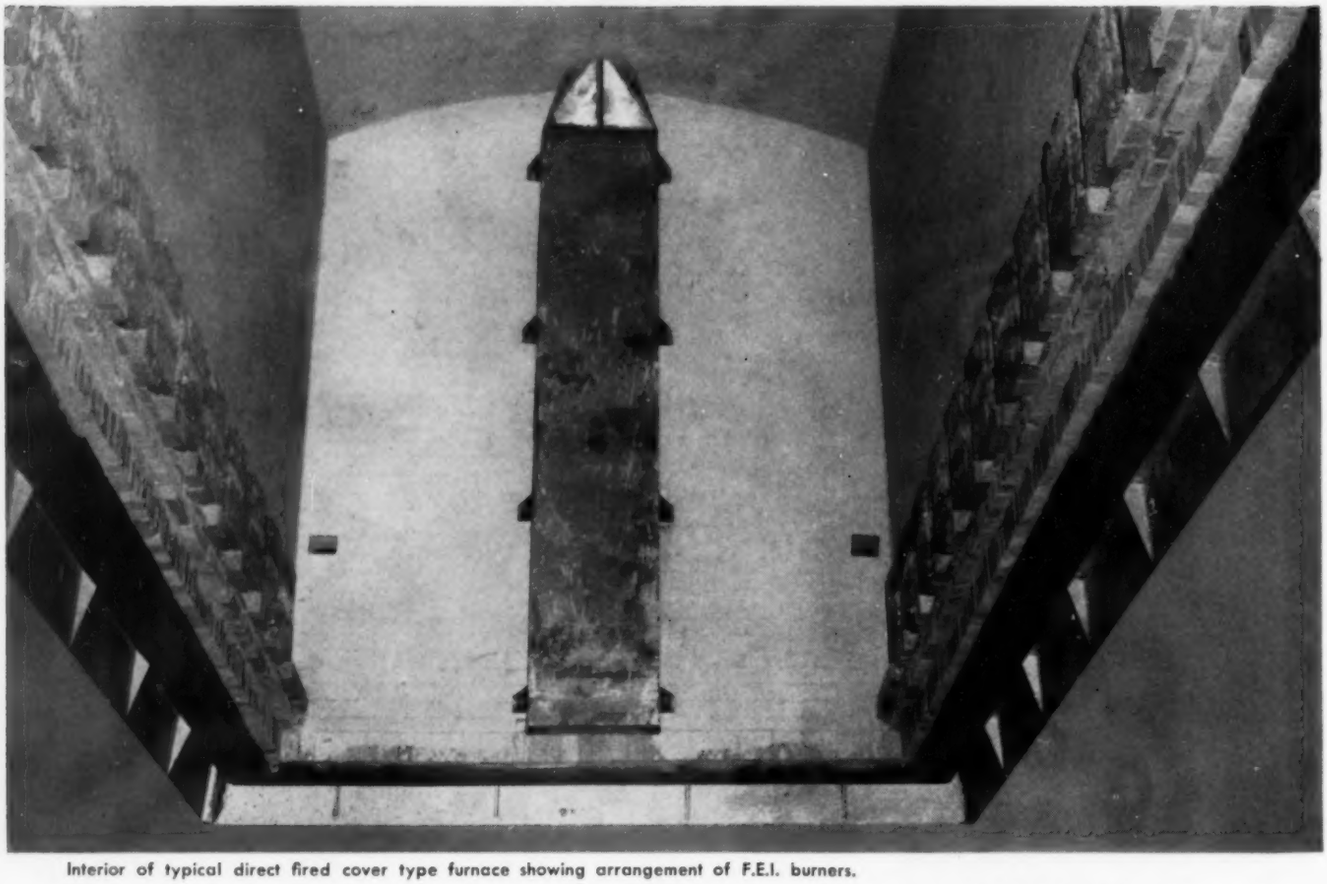
Name .....

Company .....

Address .....

City ..... State .....

Now Convert to an F·E·I Direct Firing Burner System



Interior of typical direct fired cover type furnace showing arrangement of F.E.I. burners.

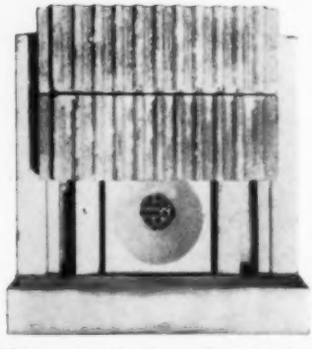
Why Pay Extra For Radiant Tubes in Cover Type Annealing Furnaces?

- Eliminate alloy tubes that are costly to maintain and difficult to procure.
- Cut fuel cost per ton through greater heating efficiency.
- Get faster heat-up . . . no tubes to limit firing temperature.
- Reduce downtime for tube maintenance—get longer continuous operation.

In many cases, the overall cost of operating a direct fired, cover type annealing furnace is less than the cost of tubes alone. Find out how F.E.I.'s patented direct firing burner system can cut your annealing costs. Conversion is simple—have an F.E.I. specialist give you the details.

F.E.I. Under New Management

Furnace Engineers is now under the management of Mr. A. A. Straub and his associates. All patents, engineering information and key technical personnel will remain with the new firm, but financial management and sales policies have been modernized in line with present day business standards.



F.E.I. patented direct firing multijet burner with lower baffle removed.

FURNACE ENGINEERS, INC. specializing in modernization of existing installations to direct firing. Also the design and construction of *new* direct fired furnaces—

- Cover Type Annealing Furnaces and Bases
- Car Type Annealing Furnaces
- Galvanizing Settings
- Patenting Furnaces
- Regenerative Soaking Pits.

Furnace Engineers, Inc.

212 BLVD. OF THE ALLIES • PITTSBURGH 16, PA.

Send For This Bulletin—Describes all types of F.E.I. heat treating furnaces.

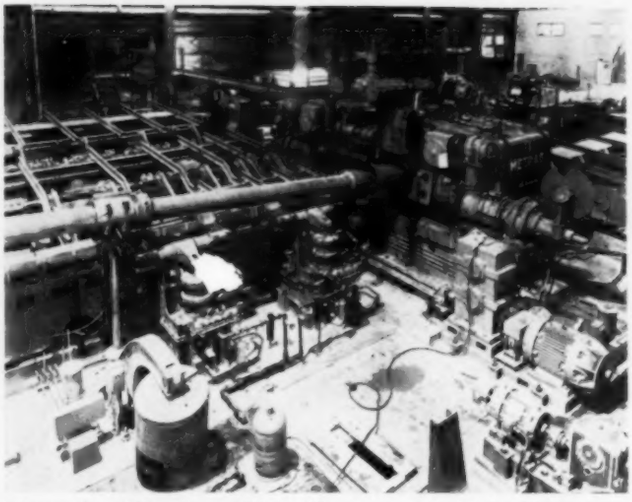


Figure 1 — Piercing mill at Mannesmann Tube Company, Ltd.'s new $20,000,000 seamless tube mill in Sault Ste. Marie, Ontario, started operations on June 15th.

New Canadian Tube Mill Begins Operation

▲ THE new seamless tube mill of Mannesmann Tube Co., Ltd. went into operation June 15 at Sault Ste. Marie, Ontario. The mill is located on a 35-acre plot which was leased for 99 years from Algoma Steel Corp.

Highly mechanized, the mill is rated at 225 tons per year of seamless oil well casing, line pipe, refinery and hot-finished mechanical pipe, and couplings.

The mill consists of two rotary piercers, a plug mill, reelers and a sizing mill. It is designed to roll seamless pipe from $4\frac{1}{2}$ in. to $10\frac{3}{4}$ in. outside diameter.

Steel rounds are brought to the mill directly from the Algoma Steel billet yard in 25-ton lots by straddle carriers. The rounds are torch cut into the desired lengths and then heated in an automatically controlled rotary hearth furnace. This furnace is fired with coke oven gas from Algoma Steel. Following the piercing and rolling operations, pipe passes to a chain-type cooling bed, from which it is conveyed to a rotary straightener. Between the sizing mill and the cooling beds, the pipe is automatically weighed and measured by a machine which records those figures. The finishing department also includes facilities for inspection, cutting-off and threading. Inspection includes x-ray checking of wall thickness, with paint being sprayed automatically on unsatisfactory sections. An automatic hydrostatic pressure test completes the inspection.

Extensive use is made of radiation cells, actuated by the heat from the pipe itself, to control the successive movements of the pipe through the mill.

The mill has a connected load of more than 22,000 hp.

General engineering of the project was carried out by Mannesmann-Meer Engineering and Construction Co., Inc., Easton, Pa., and mill equipment was built by Mannesmann-Meer A. G. in West Germany. The rotary hearth furnace was supplied by Salem Engineering of Toronto. Most of the electrical equipment and the extensive electronic control systems were installed by General Electric of Canada.

The project is said to have cost approximately $20,000,000.

Figure 2 — Plug mill has a radically new design which gives specified pipe wall thicknesses at higher operating speeds than heretofore possible.

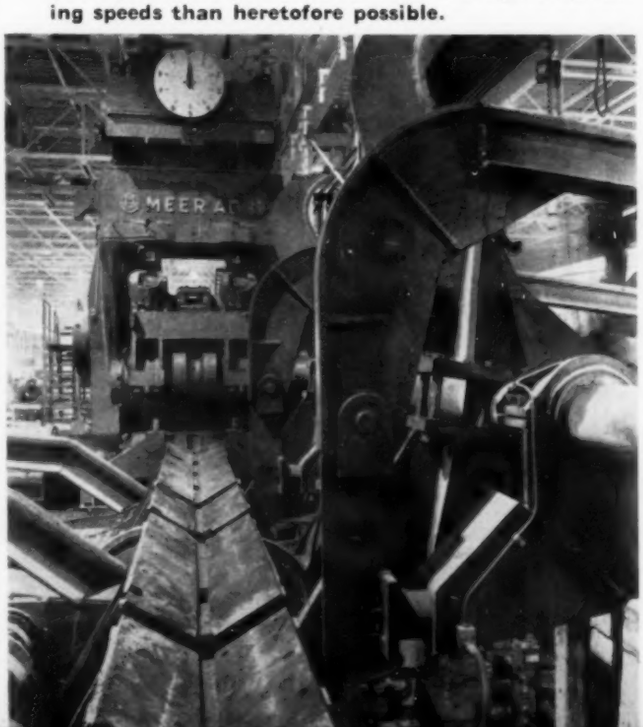
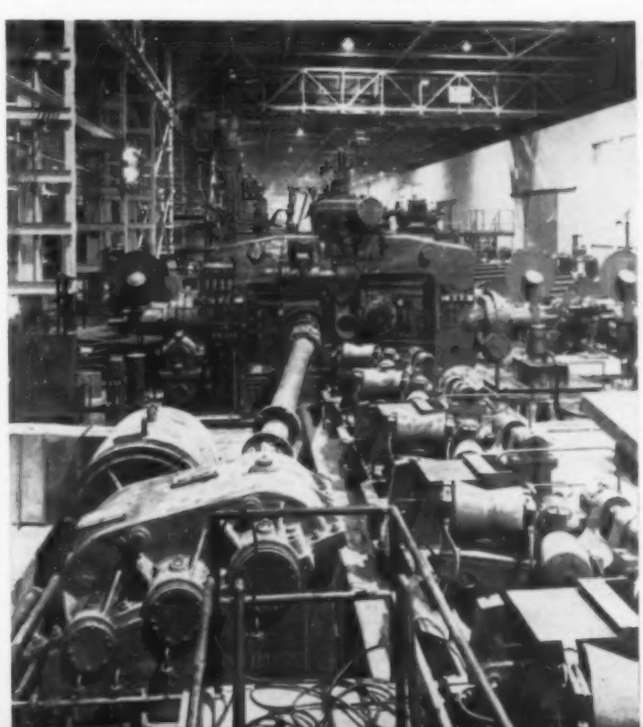


Figure 3 — A new type reeler provides greater dimensional accuracy in seamless steel pipe production.



NEW! the

. . . a triumph in mill motor design!

■ round fabricated steel frame

Compact, rugged split-frame construction assures rigidity, durability and easy access.

■ silicone-insulated windings

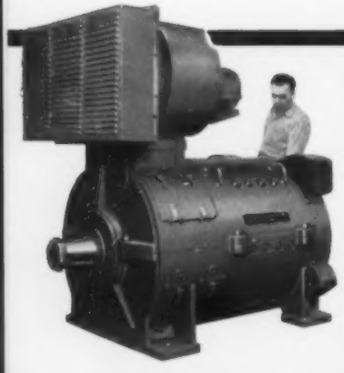
All windings are Class H silicone insulated, capable of taking the severest kind of abuse.

■ greater power

The new Elliott Crocker-Wheeler 620 is an addition to the mill motor line—more powerful than any previous design.

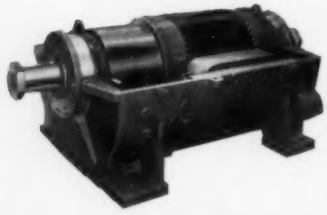
available now!

This is the recently standardized AISE 620 frame mill motor, and is now in production. Can be furnished as totally enclosed; protected self-ventilated; or as protected or enclosed forced-ventilated.



LEFT—The new 620 mill motor arranged for protected forced ventilation, with motor-driven blower and filter.

RIGHT—Split-frame construction permits easy access for maintenance and repair.



W7-4

ELLIOTT Company

JEANNETTE,
PENNSYLVANIA

ELLIOTT CROCKER-WHEELER

620 MILL MOTOR

Call the Elliott Man

at your nearby Elliott District Office or write the Elliott Company, Crocker-Wheeler Division, Jeannette, Pa. ASK FOR BULLETIN PB 9000-2.

LOCKHART— LAST OUTPOST OF HAND PUDDLING

▲ MORE than 500 business executives and customers of Lockhart Iron and Steel Co., toured the company's McKees Rocks plant recently to see the last hand iron puddling operation still producing in America.

Located in McKees Rocks since its incorporation in 1890, Lockhart Iron and Steel Co. is a pioneer metal producer in the tri-state area. Initial production in this plant consisted of the hand puddling and busheling of wrought iron, forging, and the rolling of wrought iron billets, bars and bar shapes. The plant blossomed to a peak of operation during World War I with approximately 1000 employees.

The demand for wrought iron being great at that time, the company started to stock iron products and gradually assumed the proportions of a wrought iron warehouse as well as a producer. As demands for steel grew, wrought iron stocks were supplemented with steel products stocks until today Lockhart has the largest stock of hot rolled and cold finished bars in the tri-state area. Other steel products in this warehouse stock include plate, floor plate, structural sections, reinforcing bars, sheet and strip.

In recent years the demand for hand-puddled wrought iron has been steadily decreasing, which has made Lockhart iron production secondary to its warehousing activities. The warehouse is particularly well equipped to perform all types of shearing to size and length on all products, and also for multiple flame cutting of special shapes from any thickness of plate. Equipment includes shears, cold saw, friction saw, hacksaws, angle straightening equipment and flame cutting equipment.

The company owns and operates its own fleet of trucks which include both conventional trucks and tractor-trailer units.

Warehousing space at present includes more than 130,000 sq ft for the stocking of both steel products and wrought iron, and a new extension is being added which will increase this total by 10,000 sq ft.

Over 95 per cent of Lockhart's present stocks are purchased from the major steel producers. However, Lockhart still rolls special shapes in steel and wrought iron used mainly by the ornamental iron fabricators, and special hot rolled sections for cold drawing special shapes.

At the left, a hand-puddled "sponge" is taken from a furnace at Lockhart Iron and Steel Co., the last company using this process in the United States. The modern method of wrought iron production is to melt and purify pig iron and pour it into a molten slag of iron silicate. At the right is a view of this pouring operation at the A. M. Byers Co.

Merchant Mill roughing stand

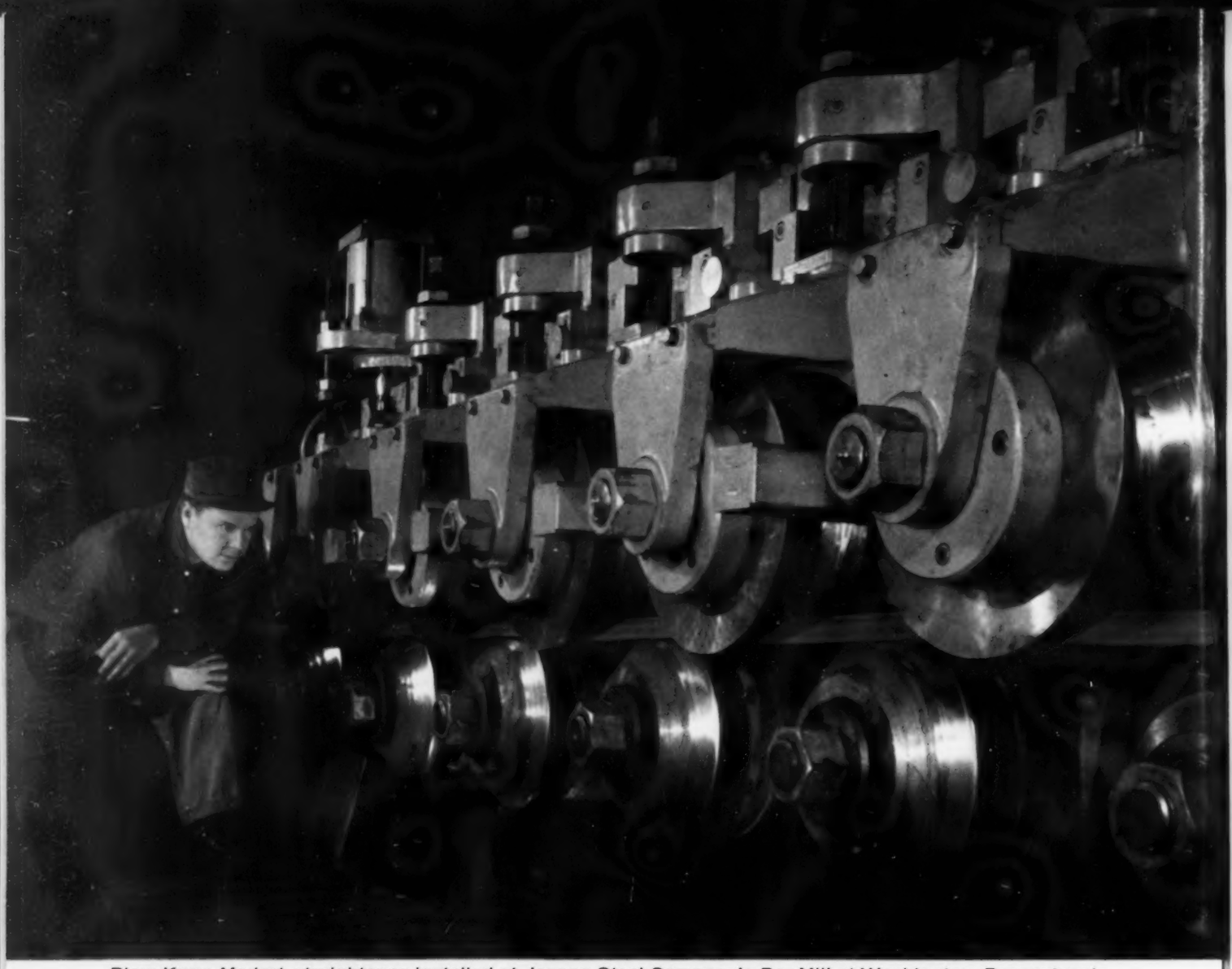
BLAW-KNOX MERCHANT MILLS

Blaw-Knox designs and builds Merchant Mills in a complete range of sizes, complete with auxiliary equipment to meet individual requirements. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations including all auxiliary equipment for ferrous and non-ferrous metals, iron, alloy iron, and steel rolls, Medart cold finishing equipment, carbon and alloy steel castings, fabricated steel plate or cast-weld design weldments, steel plant equipment, heat and corrosion resisting alloy castings.

BLAW-KNOX

BLAW-KNOX COMPANY

Foundry and Mill Machinery Division
Blaw-Knox Building · 300 Sixth Avenue
Pittsburgh 22, Pennsylvania



Blaw-Knox-Medart straightener installed at Jessop Steel Company's Bar Mill at Washington, Pennsylvania

BLAW-KNOX Medart straightener

cuts time 75% on stainless bars and shapes!

This 11-roll Blaw-Knox–Medart shape straightener installed at Jessop Steel's bar mill does its job 75% faster than the equipment it replaced. This increased performance is due to two exclusive Medart features. All straightening is done in a single pass, cutting handling time to the bone. And set-up time is only a matter of a few minutes, can be accomplished easily to handle a wide variety of flats, squares, and angles.

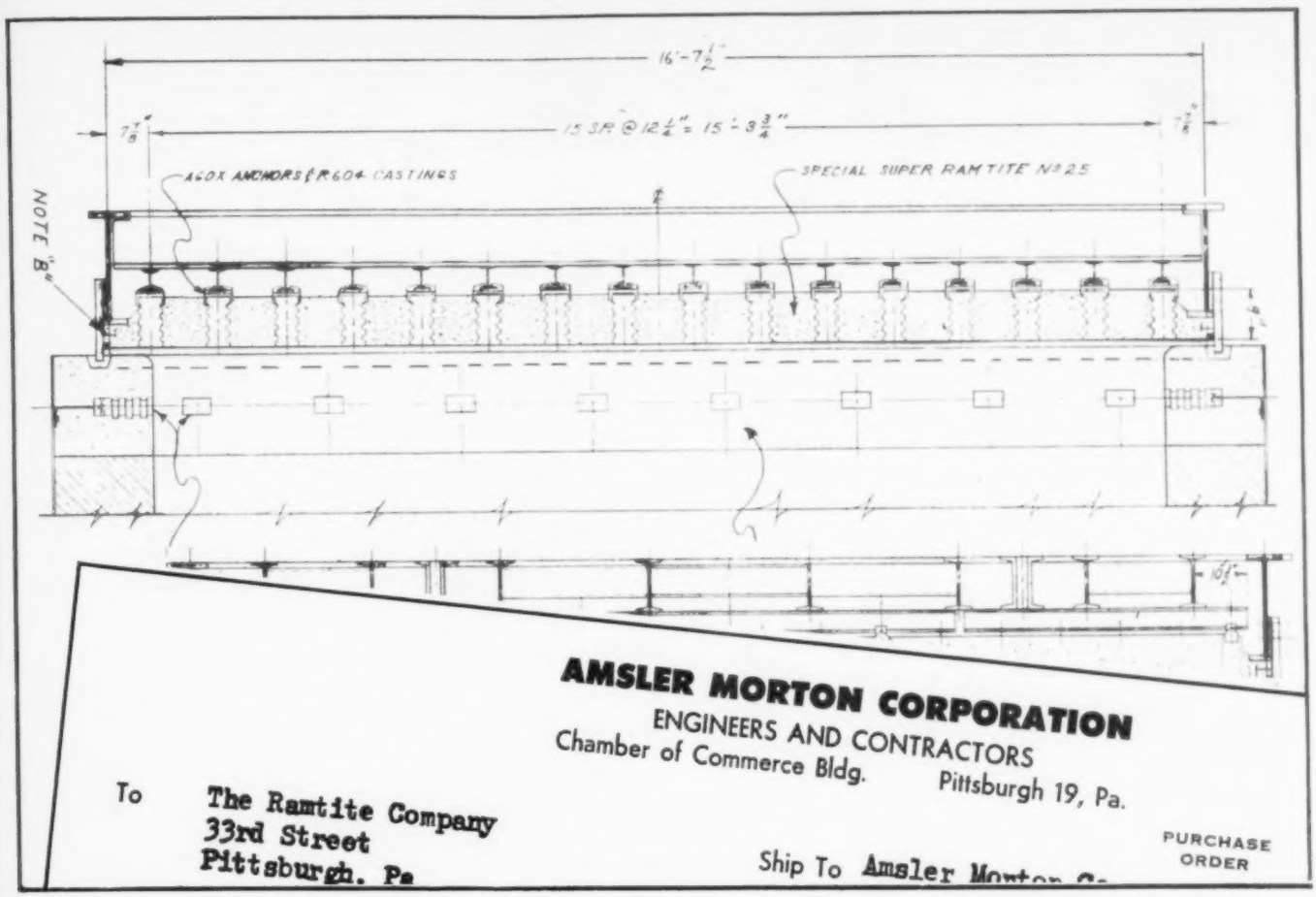
Profit-wise companies throughout the industry are experiencing results like this on *tough* straightening jobs as well as standards.

Blaw-Knox–Medart machines are the most complete line of shape straighteners in the world. Their exclusive features are engineered for uniform, high output. You can get any combination of overhung or yoke-mounted rolls, fixed or variable centers, for fast, one pass straightening of square or hex's from ¼" to 4" and flats up to 1" x 6". Medart machines for larger sections such as structural shapes can be specially adapted for your requirements. Your Blaw-Knox–Medart sales-engineer can help you apply Medart machine exactly suited to your operations.

BLAW-KNOX

BLAW-KNOX COMPANY

Foundry and Mill Machinery Division
Blaw-Knox Building • 300 Sixth Avenue
Pittsburgh 22, Pennsylvania



Again, Past Performance Paves the Way to NEW FURNACE Orders for Ramtite®

In soaking pit covers and copings, as in other refractory applications, it's performance that counts.

This is the reason for the ever-increasing use of Ramtite and for the above purchase order for Ramtite to line new Amsler-Morton soaking pit covers and copings at a southern steel mill.

Ramtite has an appreciably lower K value than fired shapes. Being monolithic it is air-tight, gas-tight and flame-tight. Furnaces heat more steel in less time with less fuel. Also, Ramtite's resistance to the mechanical injury and thermal shock of severe mill operation has often doubled pit cover and coping life. This explains why *there are more soaking pits covers lined with Ramtite than with all other plastic and castable refractories combined.*

The Ramtite Co. offers you a complete sales-engineering service—experienced men who are always available to study your refractory problems and consult with your engineering, mason and ceramic departments about your specific needs.

For additional information, call your local Ramtite representative or mail the coupon below.

CAN YOU AFFORD NOT TO USE RAMTITE?

The Ramtite Co.
DIV. OF THE S. OBERMAYER CO.

THE RAMTITE CO., Div. of The S. Obermayer Co.
1813 South Rockwell St., Chicago 9, Ill.

Please send items checked

- ☐ Bulletin on Casting and Gunning Refractories
- ☐ Steel Plant Bulletin

Company Name _____

Attn. Mr. _____ Title _____

Address _____

City _____ Zone _____ State _____

© 1957 This is another in a series of advertisements depicting ways Ramtite Refractories serve the steel industry.

A $250,000 operating credit made possible by Dowell mill scale removal service!

This operating credit was made possible when Dowell chemically cleaned a steel company's new rolling mill before it was put into operation. By removing mill scale thoroughly, Dowell Service prevented any major, emergency shut-down caused by scored bearings or fouled lines and valves. This netted the company an estimated $250,000 operating credit.

Following the erection of this new 45 x 80, 2-high slab mill, Dowell was called in to remove mill scale and degrease the lube oil system, hydraulic and air lines, hydraulic systems for the roll changer and vertical edger, and the Bowser lube oil systems in the main motor room.

The job was accomplished in about one-half the time it would have taken the steel company to do the work itself. The cost of Dowell Service was only $21,000.

In addition to reducing the risk of mill-scale fouling, Dowell Service eliminated the costly process of prepickling or batch pickling the pipe used in the hydraulic, lube oil and air line systems.

Dowell chemical cleaning service has made possible similar savings for many companies in other industries — such as chemical, refining, paper, and the public utilities. That's because Dowell engineers are experts in the use of solvents to remove scale and sludge from process equipment, tanks, piping and lines. Dowell furnishes all the necessary chemicals, trained personnel, pumping and control equipment.

For specific information on how chemical cleaning can help you to greater profits, call the Dowell office near you. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

have Dowell clean it chemically **DOWELL**

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

June 3

▲ Titanium Metals Corp. announced an average 10 per cent reduction in titanium bar, billet, wire, plate, extrusions and non-alloy grades of sheet and strip.

▲ The AISI reports that the operating rate of the steel industry for the week of June 3 is scheduled at 88.8 per cent of capacity. This is equivalent to 2,274,000 tons compared with 2,252,000 tons one week ago and 2,380,000 tons one year ago. Index of production for the week is 141.6.

June 4

▲ The Supreme Court ruled that Du Pont's ownership of 23 per cent stock interest in General Motors Corp. violates Section 7 of the Clayton Anti-trust Act which prohibits a company to acquire stock in another company where such acquisition may have the effect of substantially lessening competition.

▲ The Commerce Department reported that manufacturers' sales (billings) in April eased to $28,500,000,000 and on a seasonally adjusted basis was $300,000,000 below March, 1957; new orders by manufacturing firms in April rose to $27,800,000,000, up $200,000,000 from March.

▲ Clare E. Bacon, general chairman of the reinforced plastics division of the Society of the Plastics Industry, Inc., advised that sales of reinforced plastics for the first quarter of 1957 were up between 20 to 25 per cent. Production for 1956 totaled 140,000,000 lb.

June 5

▲ Zinc dropped ½¢ to 11¢ at East St. Louis, despite government steps to bolster the market.

▲ A jury in the U. S. District Court at Denver found Union Carbide Corp. and Vanadium Corp. of America not guilty of Department of Justice charges of conspiring to monopolize and fix prices in the vanadium industry.

▲ Assistant Defense Secretary McNeil advised Congress that defense spending for the fiscal year ending June 30 may run as high as $38,500,000,000, or $2,500,000,000 over original estimates.

June 6

▲ Prices of steel scrap in Pittsburgh advanced $4.00 a ton for No. 1 heavy melting scrap to $51.

▲ Du Pont Co. reduced titanium sponge 50¢ a lb retroactive to June 3 to figures on Grade A-1 sponge of $2.25; on Grade A-2 $2; on Grade A-2 fines $1.65.

▲ Columbia-Geneva division of U. S. Steel Corp. shut down its No. 1 blast furnace at the Ironton, Utah plant for complete overhaul following nearly five years of continuous operation.

June 7

▲ David J. McDonald, president of the United Steelworkers, assailed the steel industry's pricing policies, declaring that the U. S. Steel Corp., who traditionally sets the steel price pattern, could absorb the wage increase scheduled for July 1 without raising prices and still show a substantial profit increase over 1956, and estimated such net profit would be $437,000,000 compared with $348,000,000 in 1956.

▲ The House Banking committee approved a bill making the Small Business Administration a permanent government agency, with lending authority increased by $270,000,000 over present limits, and also reduce the 6 per cent maximum interest rate permissible to 5 per cent on the SBA's share of a business loan participated in by a private bank. The present 6 per cent limit would be removed from the bank's share which could go at the interest rate prevailing in the area.

▲ Shipments of machine tools for the first four months of 1957 are estimated at $331,450,000, as compared to $265,150,000 in the same period of 1956.

▲ The AISI reported that the iron and steel industry's estimated payroll for April, 1957 was $332,520,000, compared with $344,185,000 for March, 1957 and $326,740,000 in April, 1956. Average hourly payroll cost of wage earners in April was $2.837 (plus $0.29 for fringes) against $2.834 in March and $2.621 in April, 1956. Total employment was estimated at 670,200 during April, against 671,100 in March; average hours worked during April, 1957 equalled 38.0 compared with 38.7 in March, 1957, and 39.7 in April, 1956.

June 10

▲ Government figures showed that construction outlays in May, 1957 were over $4,000,000,000, a "seasonal" increase of 11 per cent over April, 1957 and 2 per cent over May, 1956.

▲ Steel scrap prices in the Chicago area rose $10 to $12 a ton, to as high as $59 a ton for No. 1 railroad heavy melting, $55 for industrial heavy melting, and $47 a ton for No. 2 steel.

▲ The AISI reports that the operating rate of the steel industry for the week of June 10 is scheduled at 88.2 per cent of capacity. This is equivalent to 2,257,000 tons compared with 2,240,000 tons one week ago and 2,299,000 tons one year ago. Index of production for the week is 140.5.

June 12

▲ The Labor and Commerce Depts. report that civilian employment rose to 65,200,000 in mid-May, an increase of 900,000 over mid-April; the increase was caused by seasonal agricultural and construction employment. Factory employment dropped 120,000 from a month ago, and 500,000 below December, 1956, or twice the usual decline for this period.

▲ Prices of steel scrap edge up an additional $1 in Chicago area, topping the recent $10 to $12 price increases.

▲ Lead prices in New York were reduced to 14¢, off 1¢.

▲ The Lake Superior Iron Ore Assn. reported that shipments of iron ore down the Great Lakes for the week ended June 7 equalled 3,062,342 gross tons, compared with 2,981,287 gross tons in the same week in 1956.

▲ Electro Metallurgical Co. announced a price decrease of 1.5¢ a lb for all grades of silicon metal, applying to all grades, sizes, and quantities.

June 13

▲ The Labor Dept. reported housing starts increased to an annual rate of 990,000 in May, and compared with a yearly pace of 940,000 in April, and 1,146,000 in May, 1956.

▲ The United Steelworkers' wage policy committee set a maximum of two years on contracts to be negotiated in 1957 with steel fabricating companies which will expire at the same time as three-year pacts be-

tween the union and steel producing concerns negotiated in 1956.

▲ Carpenter Steel Co. of Reading, Pa., offered to exchange from 40,000 to 65,000 shares of its common stock for a new issue of Northeastern Steel common stock as part of a plan of reorganization of Northeastern Steel Corp. filed with the United States District Court in New Haven.

June 14

▲ The Justice Dept. requested the U. S. District Court in New York for a summary judgment that a merger of Bethlehem Steel and Youngstown Sheet & Tube would violate the anti-trust laws, but action was put off until autumn.

June 17

▲ Canadian Tariff Board recommended higher tariffs on steel imports from the United States which is now running at a rate of $50,000,000.

▲ The AISI reports that the operating rate of the steel industry for the week of June 17 is scheduled at 87.5 per cent of capacity. This is equivalent to 2,240,000 tons compared with 2,214,000 tons one week ago and 2,290,000 tons one year ago. Index of production for the week is 139.4

June 18

▲ Federal Reserve Board reported its seasonally adjusted index of industrial output in May dropped to 143 per cent of the 1947–49 average, one point below the April level, and two points higher than May, 1956.

▲ The Commerce Dept. reported that personal income receipts of individuals climbed to a rate of $340,400,000,000 yearly in May, 1957, which was $1,100,000,000 above April, 1957 and $17,600,000,000 higher than in May, 1956.

▲ The Aluminum Assn. reports net shipments of aluminum sheet and plate for April, 1957 totaled 116,709,000 lb, compared with 108,731,000 lb in March, 1957; shipments of foil in April, 1957 were 14,501,076 lb; in March, 1957, 15,443,198 lb.

June 19

▲ The Commerce Dept. reported that U. S. imports in April, 1957 totaled $1,117,500,000 compared with $1,130,000,000 in March, 1957 and $991,200,000 in April, 1956.

▲ ARCI reports that deliveries of new domestic freight cars in May, 1957 totaled 8824 compared with 8961 in April, 1957 and 6667 in May, 1956. Orders totaled 3423 cars in May, 1957 compared with 6429 cars in April, 1957 and 2403 in May, 1956. Backlog of cars on order on June 1 totaled 97,006 compared with 105,190 on May 1.

▲ Eastern Stainless Steel Corp. announced it will redeem on July 19, 1957, all the outstanding 4½ per cent convertible subordinate debentures due June 1, 1971.

▲ According to the Bureau of Mines, U. S. Dept. of the Interior, U. S. iron mines produced 3,717,126 gross tons and shipped 1,855,282 tons of iron ore during March, 1957. Mine stocks at the end of March totaled 11,254,281 gross tons. Imports of iron ore in March amounted to 1,458,222 gross tons; exports of iron ore totaled 105,234 gross tons.

June 20

▲ The annual report of August Thyssen-Huette A.G., Germany, showed gross sales amounting to $172,200,000, a 38 per cent increase. Net earnings for the year amounted to $3,300,000, distributed to stockholders by 8 per cent cash dividend.

▲ New declines prevailed in copper and zinc prices. Two producers reduced their price on copper to 29¼¢ a lb, down 2¾¢, custom smelters trimmed their quotations to 29¼¢. In East St. Louis zinc prices were cut ½¢ to 10½¢ a lb.

▲ State authorities reduced permissible production of crude oil in Texas in July to 3,033,604 barrels daily, which is 384,631 barrels a day below the current allowable.

▲ The Industrial Heating Equipment Assn. reported that orders for industrial furnaces during May, 1957 amounted to $3,994,000, compared with $3,667,000 in May, 1956.

June 21

▲ GM will market its Europe-built Vauxhall and Opel cars in the U. S. next September, with prices expected to be below the Chevrolet line.

▲ Universal Cyclops Steel will submit a proposal to share holders on increased indebtedness to $15,000,000 from nothing and to increasing capital stock from 1 to 3,000,000 shares.

▲ Blast Furnace "A" of the Pittsburgh Coke & Chemical Co., Neville Island plant, was blown out for complete relining, modernization, and the addition of gas cleaning equipment. The furnace, in operation since 1950, produced over 1,500,000 tons of merchant pig iron.

June 22

▲ The Aluminum Assn. reports primary aluminum production in the United States during May, 1957 was 144,789 short tons compared with 138,728 short tons in April, 1957 and 150,800 short tons in May, 1956.

June 24

▲ M. E. Goetz, district manager of Republic Steel Corp., Cleveland, disclosed plans for a $14,000,000 program to build two new batteries of coke ovens to replace old battery No. 3, taken out of operation last week, and No. 2, which will be shut down around the end of July. Each battery contains 51 coke ovens.

▲ The AISI reports that the operating rate of the steel industry for the week of June 24 is scheduled at 86.7 per cent of capacity. This is equivalent to 2,200,000 tons compared with 2,181,000 tons one week ago and 2,114,000 tons one year ago. Index of production for the week is 138.2.

June 24

▲ Machine tool builders' business fell to the lowest level in 2½ years in May, declining to $41,500,000.

June 26

▲ The AISC reported shipments of fabricated structural steel in May totaled 329,626 tons compared with 313,591 tons in April 1957 and 306,223 tons in May 1956. Bookings in May totaled 291,750 tons compared with 360,351 tons in April 1957 and 358,271 tons in May 1956. Backlog in May totaled 3,416,968 tons.

▲ Steel scrap prices dropped $1 to $4 per ton in Chicago.

▲ Board of Directors of Inland Steel approved a financing program totaling $50,000,000 of First Mortgage Bonds to be used for the expansion program. New series, called Series K, will mature in 1987.

June 28

▲ United States Steel Corp. announced steel price increase averaging $6 per ton or 4 per cent effective July 1 to cover additional labor costs and benefits under the union contract going into effect at the same time.

July 30

▲ Congress will investigate steel price increases which are to go into effect on July 1.

▲ National Coal Association estimated that soft coal production in 1957 will be 506,000,000 tons.

▲ Jones & Laughlin Steel Corp. will acquire the Cold Metal Products Company which will become a division of Jones & Laughlin.

STEEL-MEN!

Corhart melting-end bridgewall, in tank described below, after 21 months and 6 days of service . . .

WHAT IS A "CORHART BALANCED FURNACE"?

THE term "Corhart Balanced Unit" does not signify a new or unusual design of glass furnace. It is used to describe *your* furnace, just as it stands, except with the more vulnerable parts *fortified* with Corhart Electrocast to that point where *all* parts of the tank—from dog-house to bottom—wear out evenly, each part delivering its full potential of life and service.

The cost of Corhart Electrocast is higher *per ton* of blocks, but analyses of cost and results in many units prove beyond question that it is by far the most economical refractory *per ton of glass produced*. Glass factory profits are determined by the cost of *finished ware* and NOT by the cost of the tank blocks.

The following is a typical example of many actual records:

	CORHART BALANCED TANK	CLAY TANK (AVE. OF 5 FIRES)
Cost, labor and materials	$11,100.00	$8,000.00
Life (days)	648	289
Tons of glass produced	22,087	7,274
Tank cost per day	$17.12	$27.70
Tank cost per ton of glass produced	$0.503	$1.10
Melting area	18 x 32	18 x 32

With the outlook for large tonnage demand and the desirability of continuous operation, such economies as these cannot long be ignored. Corhart Electrocast is the answer to the crying demand for a better glass furnace construction material. Write today for further information and proof of economy. *Address:* Corhart Refractories Co., *Incorporated*, 16th & Lee Sts., Louisville, Ky.

CORHART ELECTROCAST REFRACTORIES

HERE'S an ad of ours that appeared 24 years ago, back when only a few of the most progressive glass manufacturers would use Corhart Electrocast Refractory —"one of the world's highest-priced refractories". Today, however, Corhart Electrocast Refractories are used extensively throughout the world . . .

In 1957, Corhart 104 is still relatively new in the steel industry. It is also "one of the world's highest-priced refractories". Yet it offers open-hearth furnace operators the same opportunities for greater production and lower costs that Corhart Electrocast brought to glass manufacturers.

May we tell you the whole Corhart 104 story? Address: Corhart Refractories Co., *Incorporated*, 1640 West Lee Street, Louisville 10, Kentucky, U.S.A. SPring 8-4471.

QUALITY · ECONOMY · ENDURANCE

CORHART 104 ELECTROCAST REFRACTORY

The words "Corhart" and "Electrocast" are registered Trade Marks which indicate manufacture by Corhart Refractories Company, *Incorporated*. Corhart Refractories Co., *Incorporated*, 1602 West Lee Street, Louisville 10, Kentucky, U.S.A.—Telephone SPring 8-4471

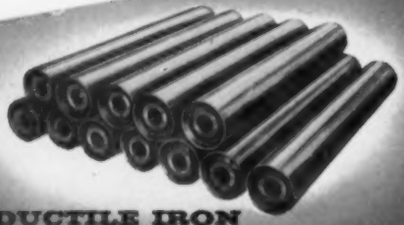
"Y.F.&M." builds the best of them!

PARALLOY

HOT STRIP COILER ROLLS • COILER PINCH ROLLS
PICKLING LINE PINCH ROLLS • UPCOILER ROLLS
CLEANING LINE PINCH ROLLS • SINKER ROLLS
CARRIER ROLLS • TEMPER MILL TENSION ROLLS

INSIDE KNOWLEDGE OF STRIP MILL PROBLEMS

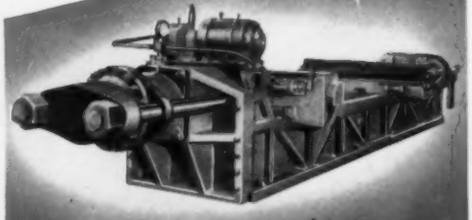
PLUS
more than
70 YEARS EXPERIENCE
building what
you need



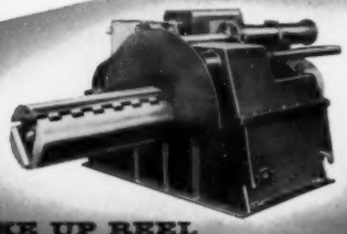
DUCTILE IRON

RUNOUT TABLE ROLLS
HOLDING TABLE ROLLS
LOOPER TABLE ROLLS
LOOPER TABLES
APRON PLATES

Ductile Iron Castings up to 50,000 lbs.



90" X 240" X 1/4" STRETCHER LEVELER



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Complete Slitting Lines and Equipment

AUTOMATIC 36" CONTOUR ROLL LATHE

Other Capacities:
24" — 48" — 60"

YOUNGSTOWN

HOT and COLD STRIP MILL MAINTENANCE SPECIALISTS

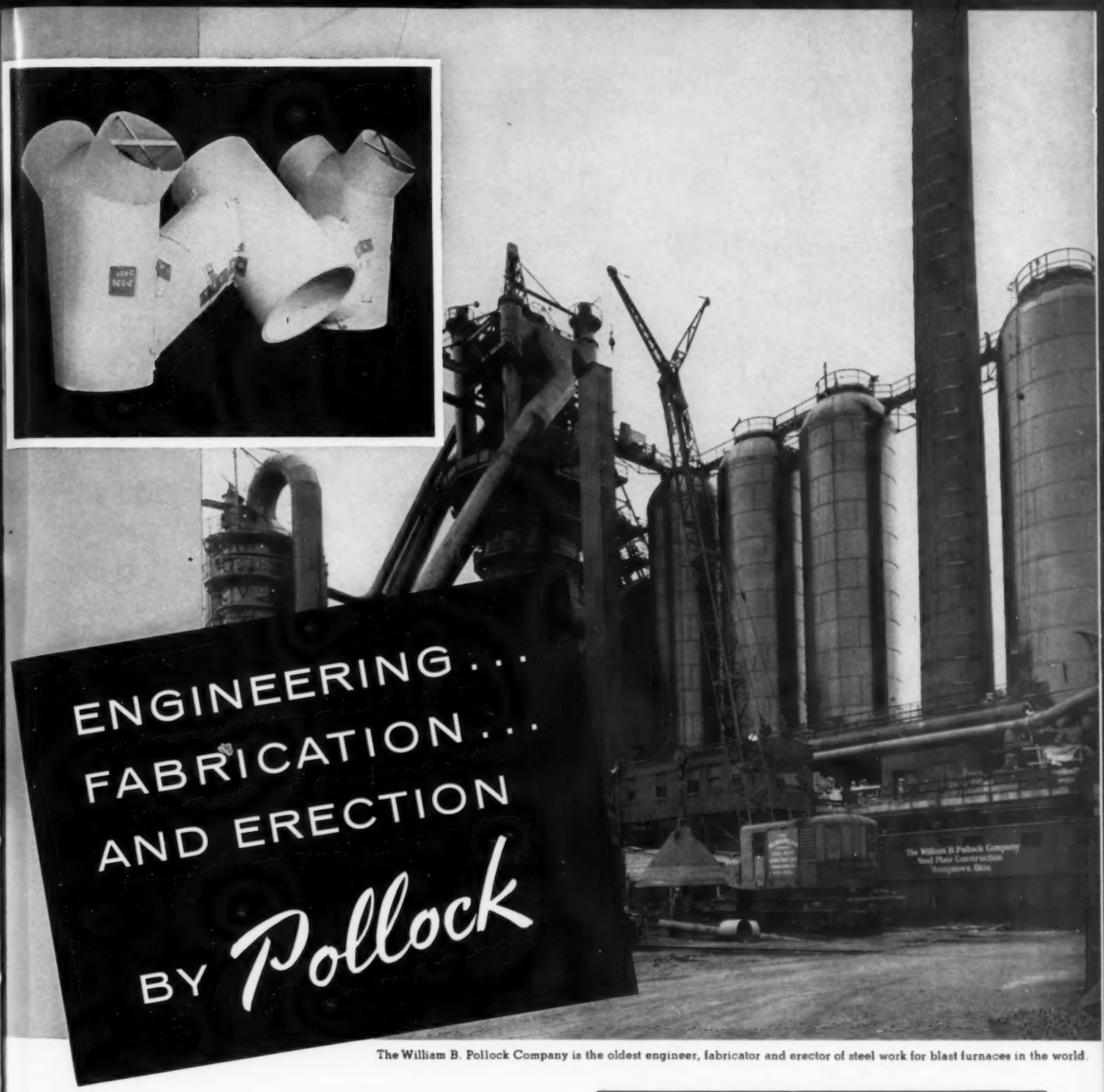
"YOUNGSTOWN" service is based on thorough understanding of strip mill problems and experience in solving them. For example, the problems of scratching, galling, pickup and excess wear are solved by the use of **PARALLOY ROLLS.** Their uniform hardness all through means you can roll more tonnage from new to scrap diameter. **"YF&M" DUCTILE IRON ROLLS** are the proven answers in overcoming heat check, warpage and cracking . . . especially good under the sprays. **"YOUNGSTOWN" MACHINERY** serves major steel mills from coast to coast.

Consult us about your problems.
Let us quote on your requirements.

The Youngstown Foundry & Machine Company

SERVING INDUSTRY SINCE 1885

Youngstown 1, Ohio



The William B. Pollock Company is the oldest engineer, fabricator and erector of steel work for blast furnaces in the world.

Only a few companies in the world can engineer, fabricate and erect the steel work for a complete blast furnace, and The William B. Pollock Company is one of them. Over the years Pollock has erected more blast furnaces than anyone in the world. We're specialists in heavy steel work, fully equipped to engineer and fabricate plate and structural requirements and do heavy machine work on castings and weldments.

Pollock engineers are at your service. Use them. They'll analyze your needs and suggest the most practical, efficient and economical solutions.

POLLOCK
Since 1863

The William B. Pollock Co.

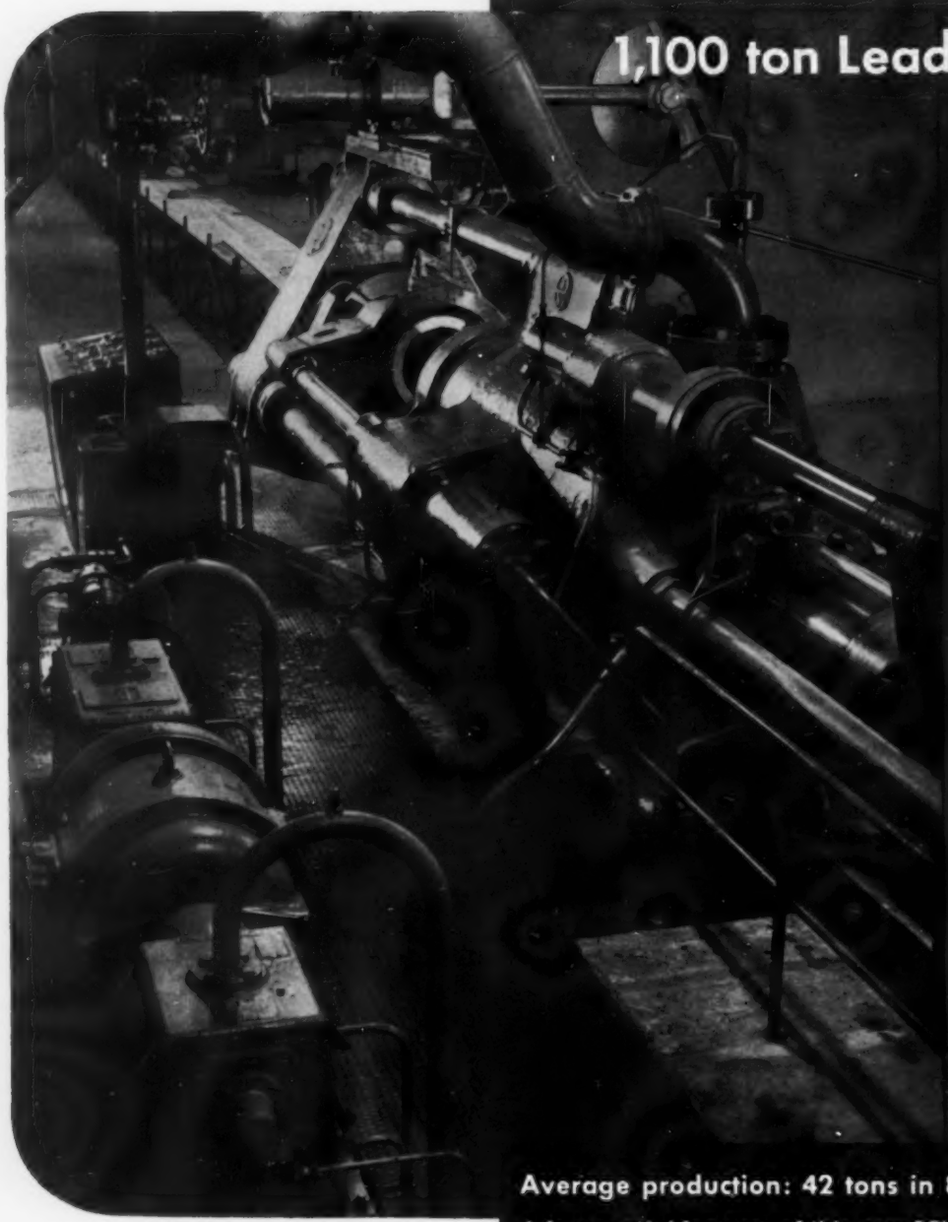
YOUNGSTOWN, OHIO

Engineers • Fabricators • Erectors
Steel Plate Construction

BLAST FURNACES • HOT METAL CARS AND LADLES
CINDER AND SLAG CARS • INGOT MOULD CARS
CHARGING BOX CARS • WELDED OPEN HEARTH LADLES

SCHLOEMANN

1,100 ton Lead Pipe Press



Average production: 42 tons in 8 hours

A few special features of this new SCHLOEMANN Press: Only three men required for the press and billet casting operation · Pre-set sequence control, if desired · Oil-hydraulic direct pump drive · Controlled electrical heating of tools and container · Rapid changing of tools · Solid and hollow billets or fluid charge may be used · Continuous extrusion of sections and pipes from 5/16 in. to 13 1/2 in. and wire from 1/16 in. upwards in two strands · Only one container for this wide range of program · Billet weight up to 750 lbs · *Further information supplied on request.*

FELLER ENGINEERING COMPANY 1159 Empire Building, Pittsburgh 22, Pa.

HOT AND COLD ROLLING MILLS · COUNTERBLOW HAMMERS · HYDRAULIC PRESSES

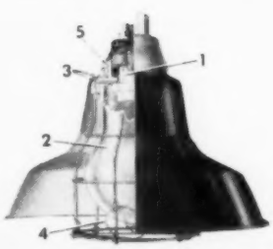
Cuts Re-lamping Costs

IN HALF!

Adapts For Larger Lamp Size

WITHOUT RE-WIRING!

New CROUSE-HINDS VAPORMASTER® Lighting Fixtures



1 *Shock-absorbing receptacle* — takes jolts from any direction. **2** *Pear-shaped globe* — plenty of clearence for lamp. **3** *Vapor-tight seals throughout* — fully gasketed construction. **4** *Globe clamping spring* — flips open for re-lamping — no tools needed. **5** *Aluminum adapter-guard* — 2 sizes fit *all* Condulet bodies.

Here is vapor-tight, shockproof industrial lighting engineered for the greatest possible economy and convenience in both installation and maintenance.

In any indoor or outdoor exposure to moisture, rain, gases, dirt, or corrosive vapors . . . a new standard of operational efficiency is set by the new VaporMaster series. Cleaning and re-lamping is done in half the time, *without tools*. Whenever a demand for a change in lighting intensity develops, a simple change of adapters accommodates the larger lamp — without touching the wiring!

Hundreds of fixture combinations may be assembled from 33 standard components to meet your varying needs. Typical choices:

- *Condulet® bodies* in pendent, ceiling or bracket types and with side hubs.
- Adapters in two forms . . . one for lamps up to 150-watts A23 . . . one for 200- and 300-watts PS30 medium base lamps. Sizes may be changed without disturbing wiring merely by installing adapter for the desired lamp.

ASK FOR CATALOG INFORMATION ON THE VAPORMASTER SERIES TODAY

Just call your Crouse-Hinds distributor . . . or nearest Crouse-Hinds office.

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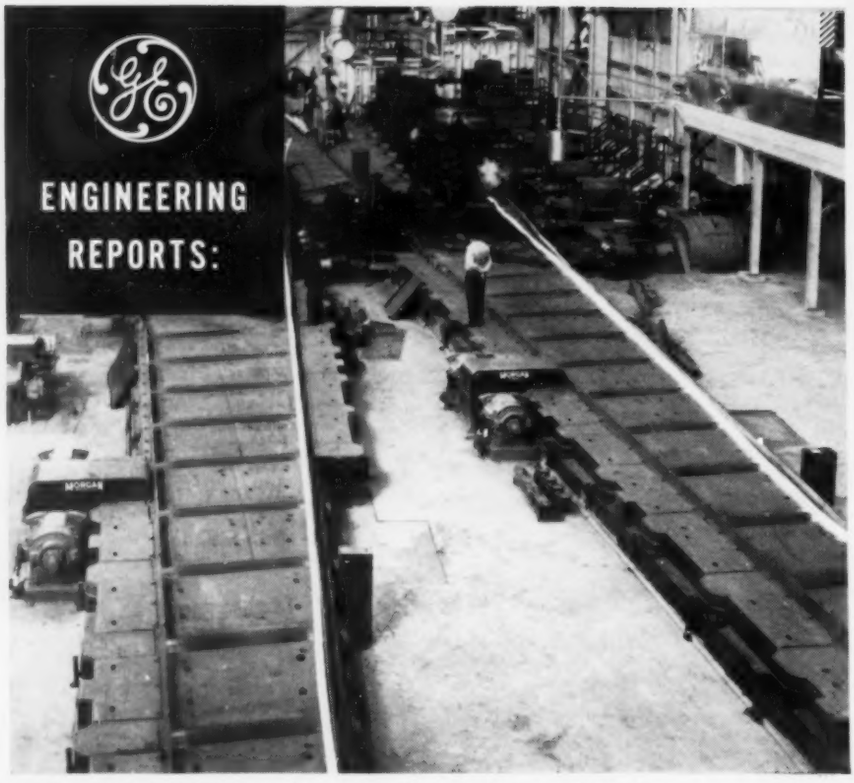
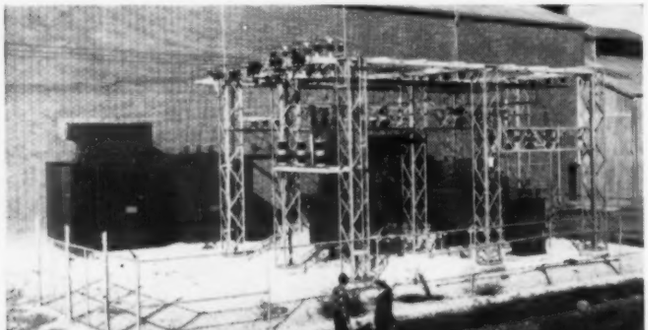
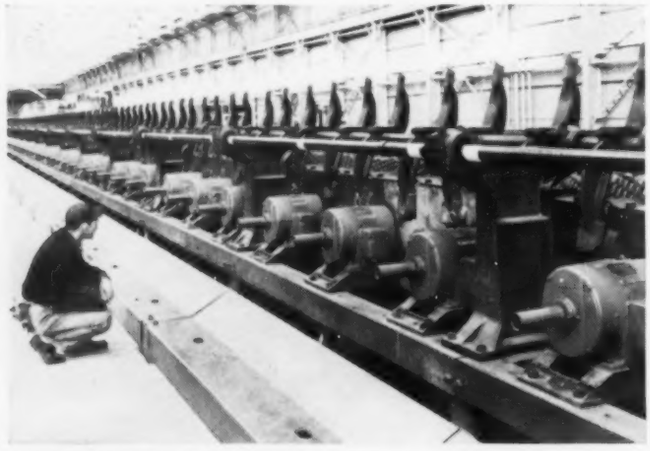


ONE OF THE FASTEST combination mills in existence, Atlantic Steel's new mill produces both rod and merchant products. Above is view of mill with skew "Y" tables in foreground.

AT ATLANTIC STEEL: pulling in

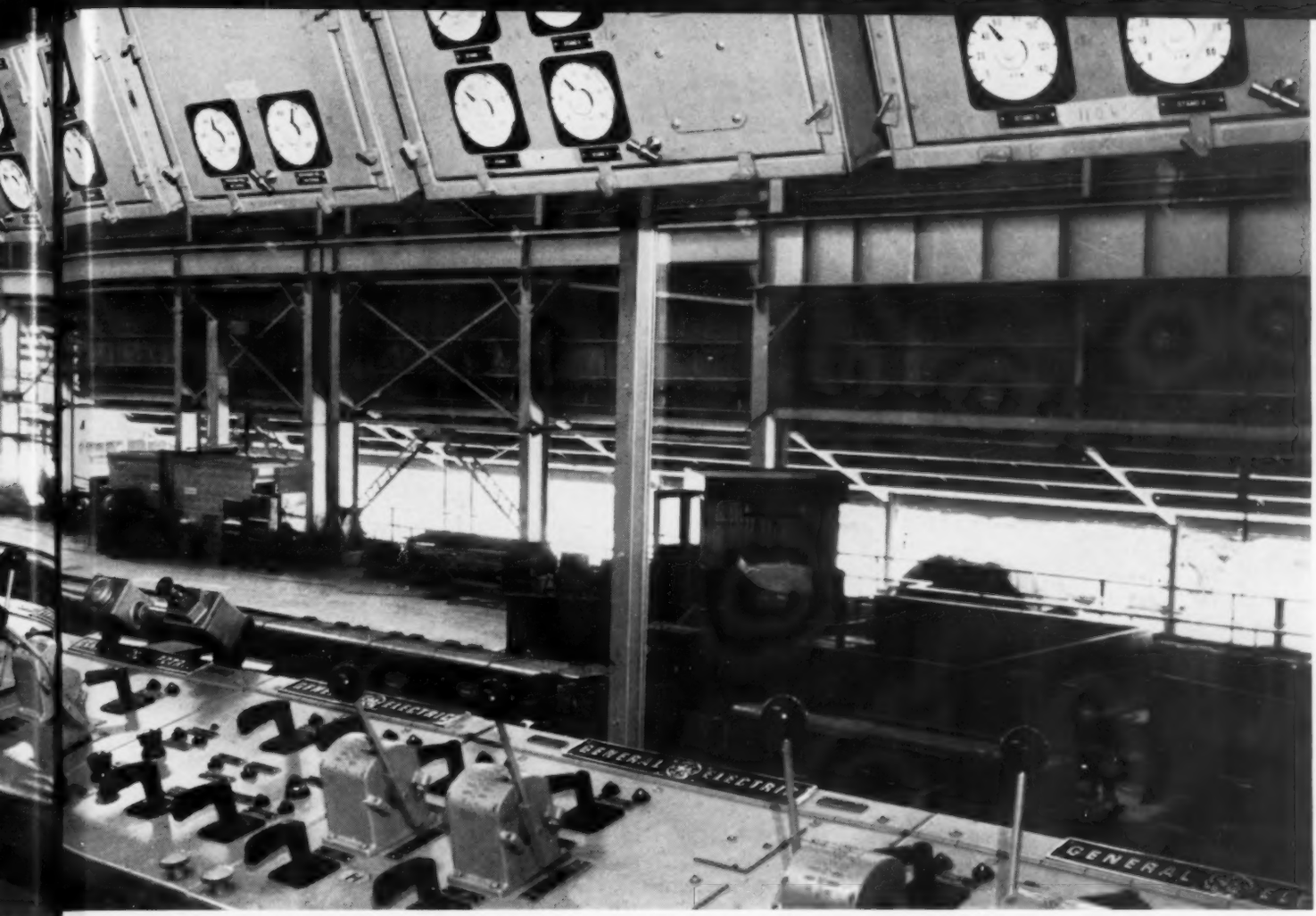


LOAD RATIO CONTROL provides best power factor, eliminates need to shut down mill to change voltage level. Rectifier regulating transformers and power circuit breakers are part of all General Electric outdoor package substation.



EASY REMOVAL of motors is facilitated by individual plug type connectors for each of 123 Tri-Clad* '55' 1-hp, adjustable frequency, a-c motors installed on cooling bed runout table.

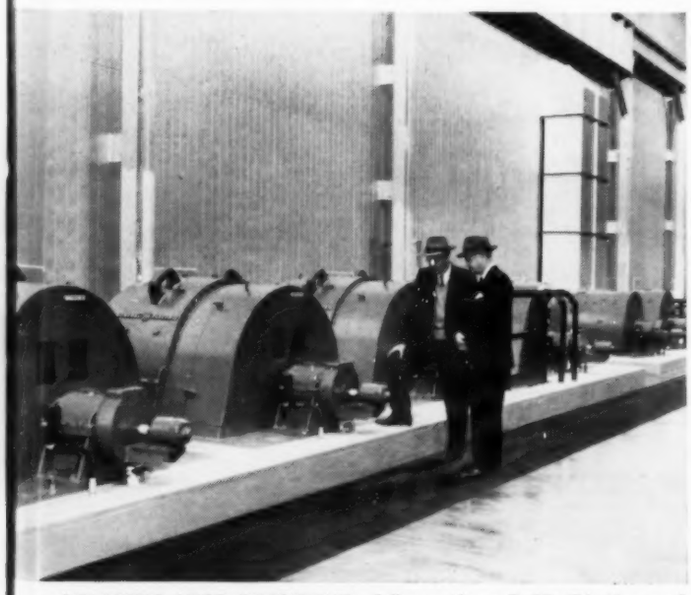
HIGH EFFICIENCY power supply is provided by these 1500-kw and 3500-kw mercury arc rectifier unit substations. Package construction provides lower installation cost, greater safety.



CENTRALIZED OPERATOR'S CONTROL of the mill is carried out from this air conditioned pulpit, located above the mill floor.

New drive system reduces buckling and one of world's fastest combination mills

General Electric's new speed regulators also shorten rescheduling time



ATLANTIC VICE PRESIDENT of Operations J. H. Girdler and General Electric Sales Engineer R. P. Crockett inspect General Electric main-drive motors totalling 8450 horsepower.

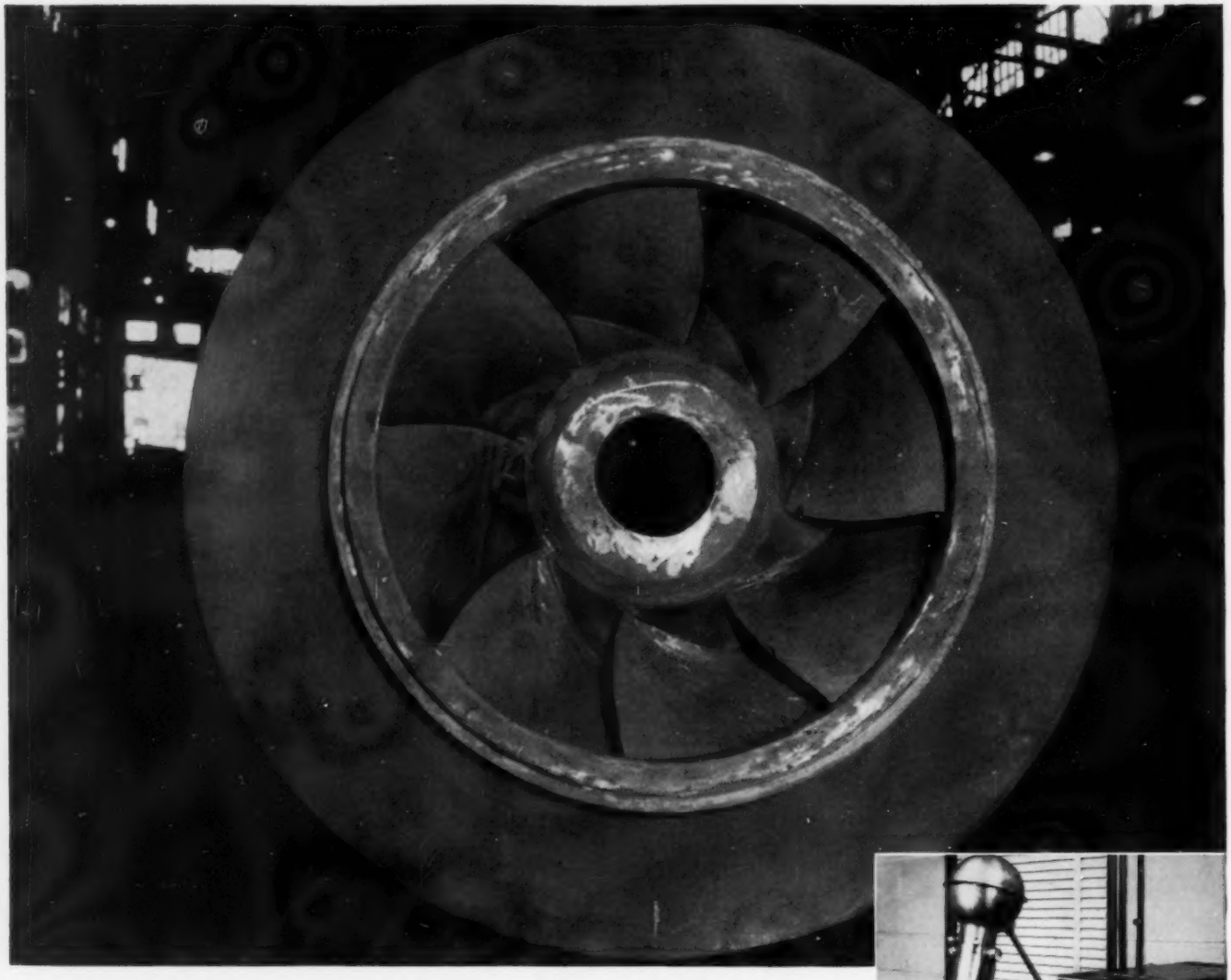
The Atlantic Steel Company's new combination merchant bar and rod mill, powered by a General Electric co-ordinated drive system, is the South's newest and most modern rolling mill. Its maximum delivery speed of 5000 fpm for rods and 2000 fpm for merchant products makes it one of the world's fastest combination mills.

THE DRIVE SYSTEM has standard mill motors with new amplistat-amplidyne regulator designed to hold 0.25% steady-state speed error from no-load to full-load. The regulating system makes it possible to set no-load speed essentially equal to rolling speed for fast set-up and rescheduling. In addition, the system provides faster response —to reduce over- and underfeed due to impact speed drop.

THIS MODERN, NEW MILL DRIVE system was the result of close co-operation between Atlantic Steel personnel, The Morgan Construction Co., Rust Engineering Co., and G-E engineers. *G-E engineers are also ready to work with you and your consultants to help meet production requirements. Get complete information from your nearest Apparatus Sales Office.* General Electric Co., Section 659–116, Schenectady, New York. **Registered trade-mark of General Electric Company*

Engineered Electrical Systems for the Steel Industry

GENERAL ELECTRIC



Pump runner weighing 11,000 lb. and cast of Composition "G" at Baldwin-Lima-Hamilton's Eddystone Division. This special Baldwin alloy, 87.5% copper, 8% tin, 4% zinc and .5% nickel, has a tensile strength of 50,000 psi. It is extensively used for shaft liners, bushings, air valves, pump cases and covers, impellers, and valve bodies.

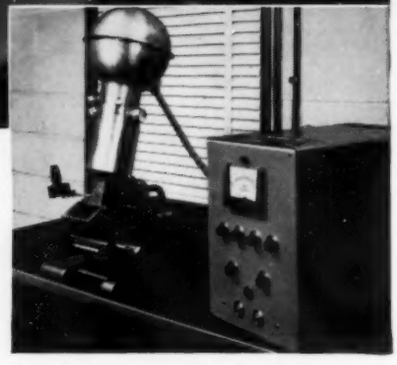
Hub section of 11,000 lb. pump runner cast by Baldwin passes inspection of 1,000,000-volt X-ray unit

When Baldwin makes your castings, you know you get precisely what you specify. The hub section of this 11,000-lb. pump runner for the Byron Jackson Company, Los Angeles, Calif., went under the penetrating eye of Baldwin's 1,000,000-volt X-ray unit and was conclusively proved to meet the specifications.

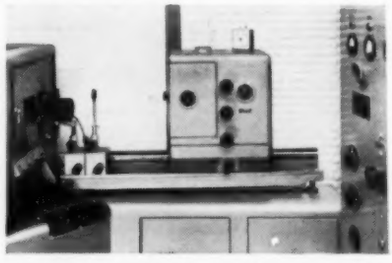
Made of Baldwin's own Composition "G," this runner was cast in cement bonded molds, which assure greater accuracy of pattern and minimum cleaning in the vane sections.

B-L-H's Eddystone and Standard Steel Divisions have both the skills and the facilities to produce any casting you need. So whatever your casting problem, you can turn to Baldwin with complete confidence.

For a copy of our illustrated Foundry Bulletin 6002, write to B-L-H Corporation, Philadelphia 42, Pa.



Electron microscope used by Baldwin to insure strict quality control of its foundry products where specified.



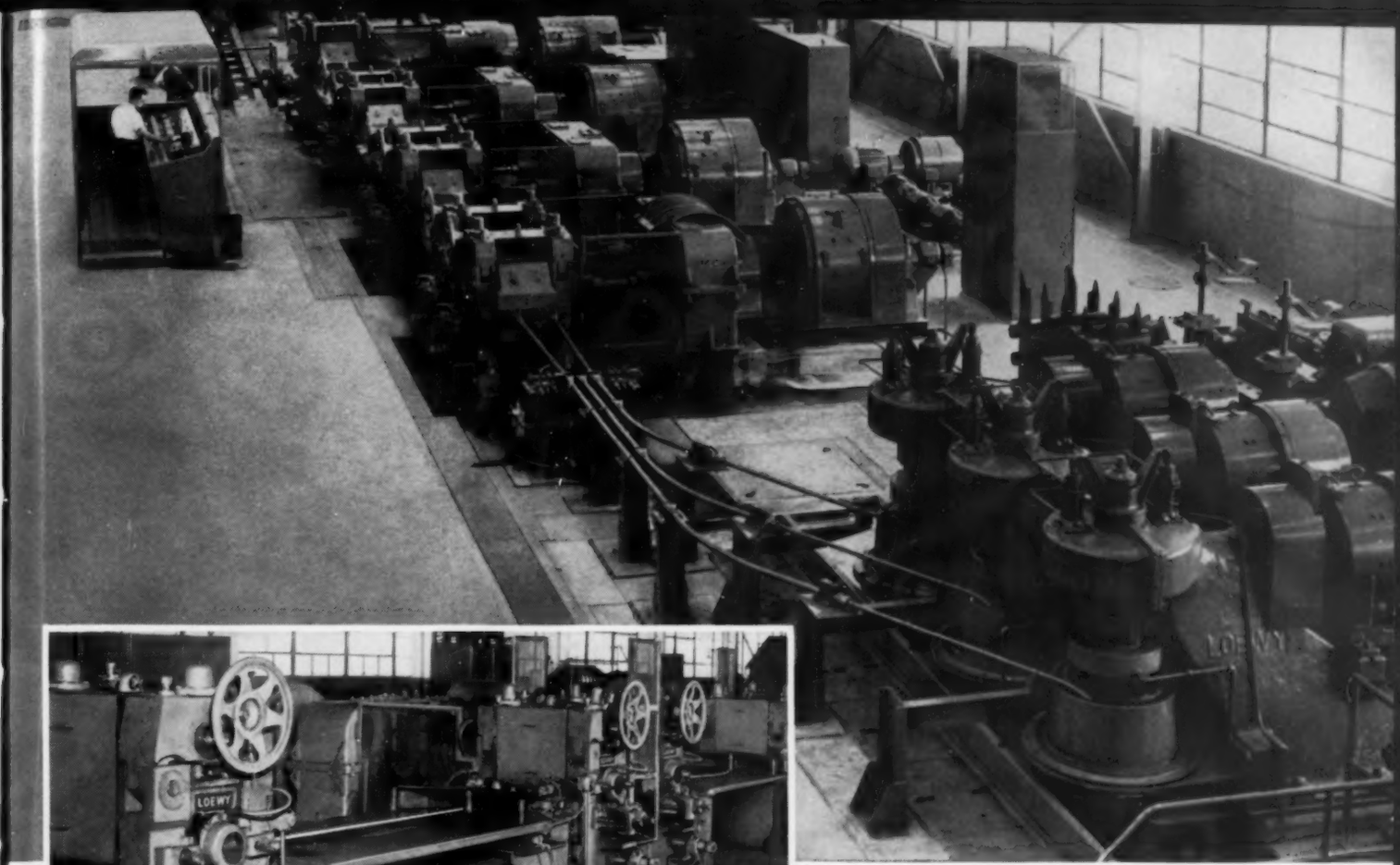
The spectroscope is also in wide use at Baldwin. It has proved invaluable in many research projects dealing with nonferrous castings.

BALDWIN · LIMA · HAMILTON

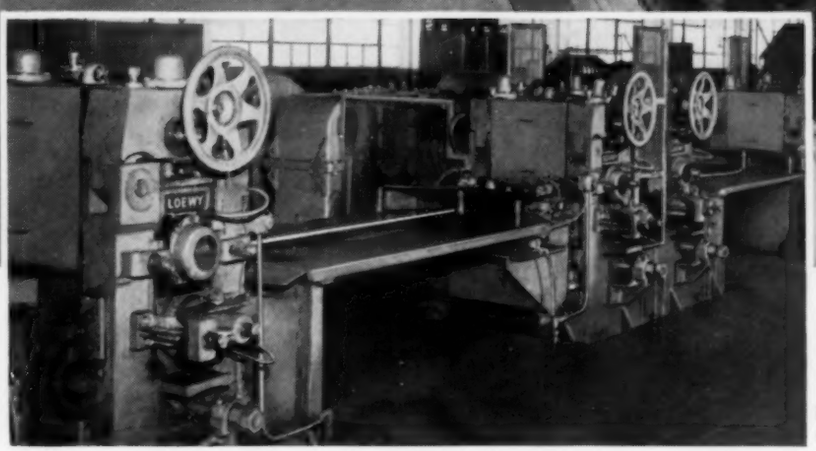
Eddystone Division

Philadelphia 42, Pa.

Hydraulic turbines • Weldments • Dump cars • Nonferrous castings



Continuous wire rod mill installation for 2-strand operation.



Part of 12- and 10-in. continuous finishing train of a wire rod mill showing entry side for 2-strand operation.

Even with inexperienced crews, Loewy wire rod mills for steel and nonferrous metals function flawlessly

This automatic rolling mill has been in operation now for one year, and its owner is well satisfied with it in every respect. In addition to the excellent products and high output obtained, he is extremely pleased with the fact that despite the inexperience of the crew assigned to it from the start, the installation has operated without difficulty.

On nonferrous metals, our wire rod mills operate at 2400 fpm and more. On steel, of course, speeds up to 6000 fpm can be obtained. Loewy rolling mills are engineered for top output, labor-saving production, and minimum maintenance.

Loewy designs, builds and installs blooming mills, slabbing mills, hot and cold strip mills, rail and structural mills, billet mills, skelp mills, merchant mills, foil mills, laboratory mills, all kinds of special mills and auxiliary equipment.

We work with you from the earliest planning stage, taking your initial concept and developing it through every phase of the project to full-scale plant operation. We also specialize in modernization of existing rolling mills. If you would like more detailed information, write us today, Dept. C-7.

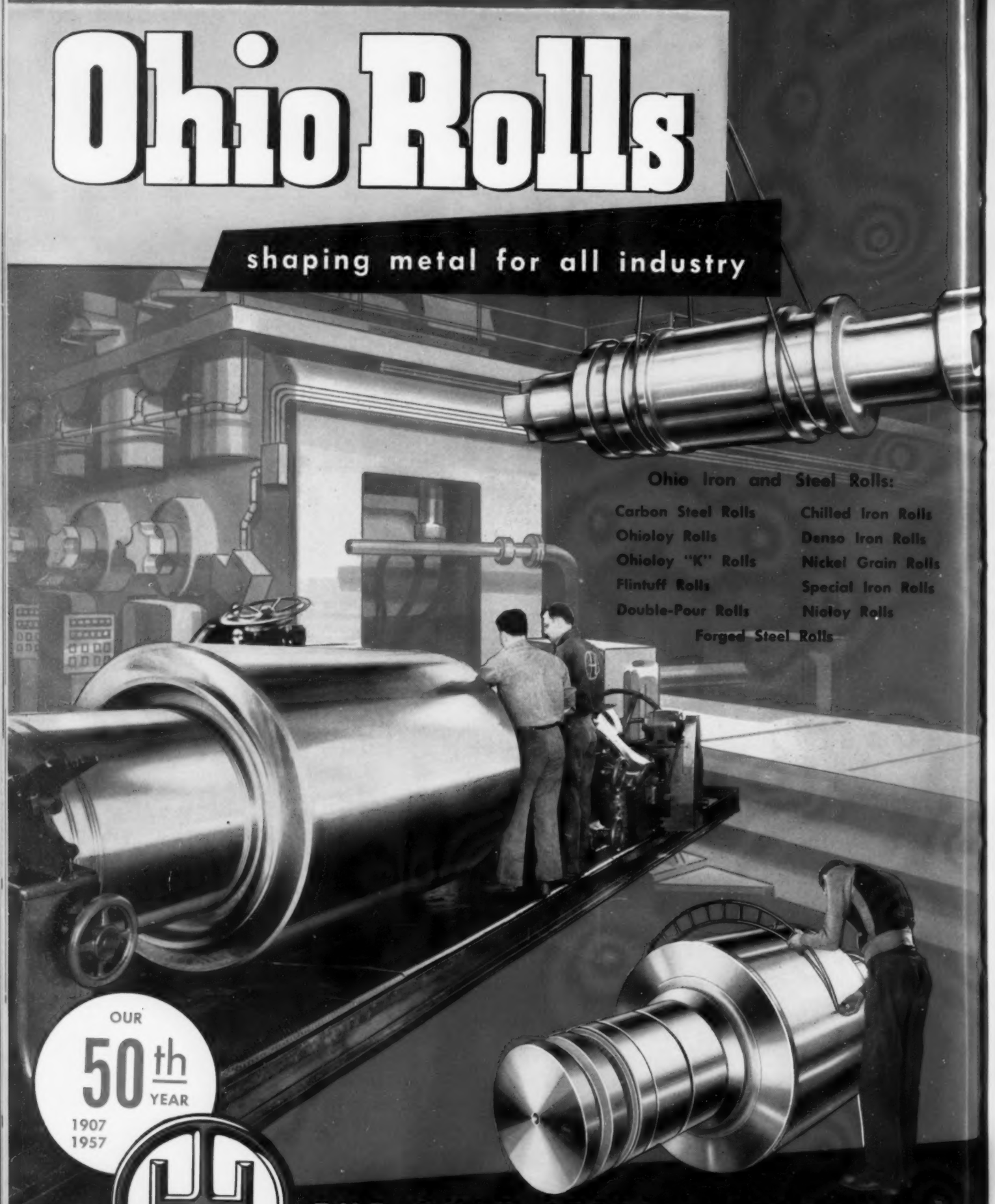
Loewy-Hydropress Division

BALDWIN · LIMA · HAMILTON

111 FIFTH AVENUE, NEW YORK 3, N.Y. Rolling mills • Hydraulic machinery • Industrial engineering

Ohio Rolls

shaping metal for all industry



Ohio Iron and Steel Rolls:

Carbon Steel Rolls	Chilled Iron Rolls
Ohioloy Rolls	Denso Iron Rolls
Ohioloy "K" Rolls	Nickel Grain Rolls
Flintuff Rolls	Special Iron Rolls
Double-Pour Rolls	Nicloy Rolls
Forged Steel Rolls	

OUR 50th YEAR
1907
1957

THE OHIO STEEL FOUNDRY CO.
LIMA, OHIO

Plants at Lima and Springfield, Ohio

OR13

Industry News...

ROEBLING EXPANSION NEARING COMPLETION

▲ A $2,500,000 installation of new production facilities for high voltage power cable and other electrical wire products at the John A. Roebling's Sons Corp. is nearing completion.

According to Charles R. Tyson, executive vice president of Roebling, the expansion "will enable us to meet the needs of the utilities and the mining and construction industries for high voltage cable in longer lengths of 1000 ft or more. Demand for this type of cable has multiplied ten-fold since 1920, and we expect this market to double again within the next five years."

New vulcanizing equipment, capable of insulating power cable of 3000 ft and more in length, is now in operation and the quality of cable produced to date on this equipment surpasses expectations, Mr. Tyson said.

The new installations also include a precision paper-taping machine, one of the largest and most modern in the country, which can turn out power cable ranging from ¼ in. to nearly 3¾ in. in diameter.

New equipment has been installed for the manufacture of paper power cable for use by utilities and industrial plants. A new building has been completed to house the new cabling, insulating, vulcanizing and testing equipment for this type of cable.

"We will also use these facilities to produce low pressure gas-filled cable, a new product for Roebling," Mr. Tyson said.

In addition to the new production facilities, Roebling has installed extensive new laboratory and research equipment. This will enable Roebling to carry on expanded activities in the development of new types of cable, new insulating materials and other electrical wire and cable improvements.

ADDS NEW STRIP MILL AND ELECTRIC FURNACE

▲ A new electric steelmaking furnace and a new strip mill started operations at the Gadsden plant of Republic Steel Corp., during the week of June 9.

The plant's multi-million-dollar expansion program, which has been in the construction stage for two years, will continue with the installation of a second electric furnace and certain other equipment later in the year.

The expansion at Gadsden is part of Republic's current corporation-wide growth program geared to increase ingot production capacity by two million tons—to 12,240,000 tons—by the end of 1957.

Gadsden's two new electric furnaces, which combined will be able to turn out 408,000 ingot tons a year, will boost ingot capacity there by more than 50 per cent, from the 789,000 tons at which the plant's present eight open hearth furnaces are rated, to 1,197,000 tons. The electrics are 24-ft diameter furnaces, largest in the South and largest in the world so far as their electrical capacity is concerned. They will be able to turn out 175 tons of steel per heat.

Backed by the new electric furnace capacity, the new strip mill will enable Republic to become a major supplier of flat rolled steel in the South. It will increase Gadsden's production of galvanized sheet and roofing from a former average of 4000 tons per month to 10,000 tons, and will put the Gadsden plant in the coil sheet picture for the first time.

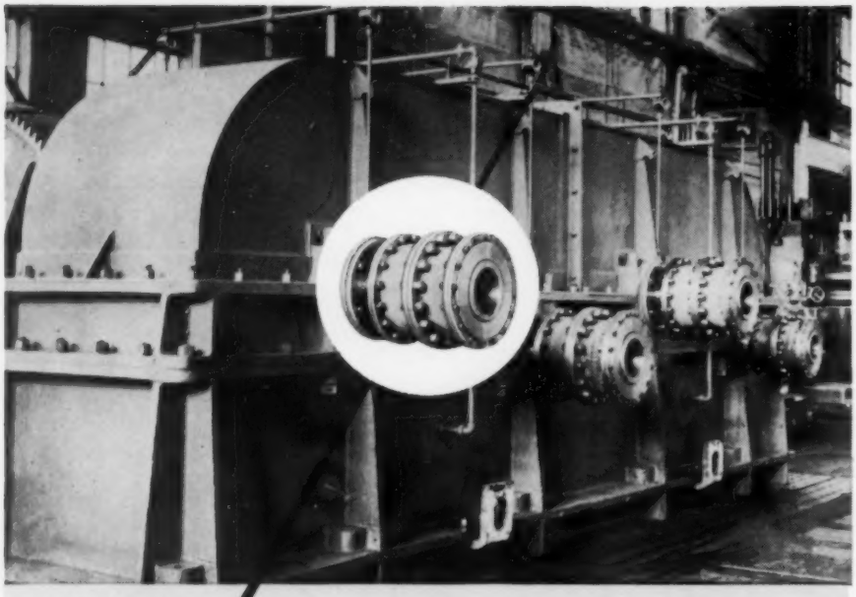
Besides the 10,000 tons of galvanized, production goals call for 13,300 tons per month of cold rolled sheets and 7000 tons of hot rolled sheets in coils or cut lengths.

The new strip mill equipment centers around a 54-in. hot strip mill and a 54-in. three-stand tandem cold mill, designed to turn out finished product up to 48 in. wide; a 54-in. temper mill; a continuous pickle line which can handle 20-ton coils; a 48-in. continuous galvanizing line; an annealing department; 48-in. cold cutting and hot cutting lines; and a multiple slitter for making narrow bands from coils.

This equipment will produce hot

EASTERN MILL ADDS REPLACEMENT TROLLEY

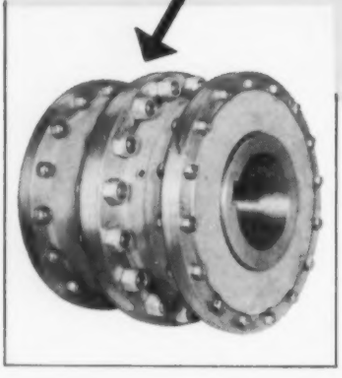
New 10-ton replacement man trolley, built by Dravo Corp., Pittsburgh, for an Eastern steel mill, will be installed on 40-year-old coal bridge like this one. Trolley on bridge shown was supplied by Dravo to same mill in 1954. The coal bridge is used both for unloading and stocking coal and reclaiming it from the storage pile to hopper cars bound for the mill's coke plant. Both trolleys support buckets of 10-ton capacity. Although the bucket size has not been increased, the mill operators have found that the trolley already installed has increased the old bridge's output. Faster operating speeds and the nearly 100 per cent elimination of downtime for repairs are credited with making the difference.



Waldron heavy duty mill type couplings on rod mill

WALDRON

flexible couplings...



USED IN HUNDREDS OF DIFFERENT APPLICATIONS BUT ALWAYS FOR THE

same 3 reasons

1 STRENGTH — Hubs and cover sleeves for sizes 1¼A through 7A are machined from tough steel forgings. Hubs are keyed to the shafts. The two one-piece cover sleeves function as a single, rigid unit serving as a floating connecting link between the hubs. High strength of forgings makes possible a very compact coupling with low rotating inertia.

2 RELIABILITY — There are no flexible parts to bend or break and the coupling is dust, moisture, and oil tight. Patented Walflex seal is positioned where centrifugal force is least. Clearance between teeth in hubs and sleeve is engineered so that an oil wedge always separates them, taking the wear.

3 SERVICE — Plenty of rough bore couplings, already assembled—on the shelf for *immediate* delivery. Finish bored standard couplings shipped to meet customers' schedules. We are geared up to give you realistic delivery on *any* type of couplings.

Ask for Catalog 57

JOHN **WALDRON** CORP.

NEW BRUNSWICK, NEW JERSEY

Representatives In Principal Cities

Export Agents—Frazar & Co., New York, N. Y.

and cold rolled sheets and galvanized sheets, all up to 48 inches wide, in coils or cut lengths.

EXPANDS RESEARCH AND DEVELOPMENT FACILITIES

▲ Recent ground breaking ceremonies initiated construction of a new research and development pilot plant building at the Electrode Division, Great Lakes Carbon Corp. plant, Niagara Falls, N. Y.

The new facility will duplicate every unit operation of carbon and graphite production. It will produce newly developed and improved graphite and carbon products on a pilot plant scale. Special equipment will provide for performance testing of graphite electrodes and anodes, and for the evaluation and development of new and advanced processing techniques.

Other features include modern instrumentation on all equipment for achieving exacting control, an area for small-scale development and testing work, a completely equipped machine shop, and a completely equipped microscopic laboratory.

The new pilot plant will expand the division's research and development activities by more than 50 per cent when the facility becomes operable in November, 1957.

LESCHEN CONSTRUCTS NEW WIRE ROPE MILL

▲ Construction has been started on building alterations and extensions for a new wire drawing mill at the Leschen Wire Rope Division, H. K. Porter Co., Inc. Construction should be completed by September and the mill is scheduled to be in operation in December.

Manufacturing equipment has been engineered and will be arranged to produce considerably more wire per sq ft than in conventional mills. Throughout the manufacturing process there will be no need for fork-lifting handling. Even the cleaning to remove oxide from the wire will be accomplished by continuous line operation rather than by the more usual batch type method of dipping coils into a cleaning solution.

At the end of the line, wire will be delivered on bobbins palletized in sets for fast, convenient movement to the wire rope stranding machines.

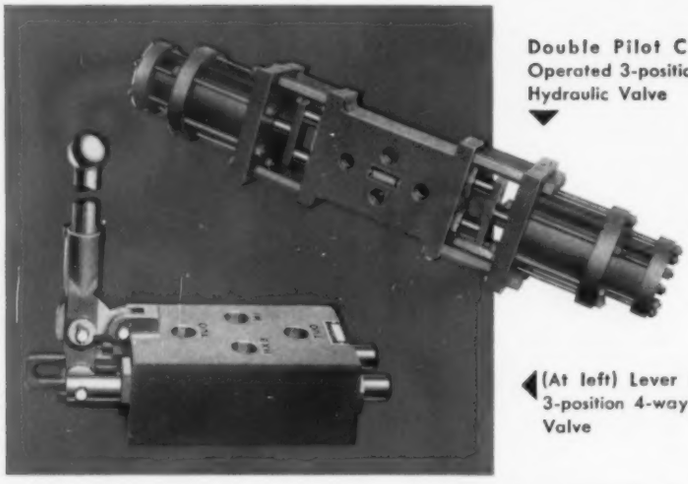
V. R. BROWNING
MILL TYPE CRANES
TO Specification
Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.

BOX 309, WILLOUGHBY (CLEVELAND), OHIO

Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

Quick-As-Wink®
HYDRAULIC VALVES



Double Pilot Cylinder Operated 3-position 4-way Hydraulic Valve

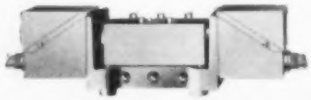
(At left) Lever Operated 3-position 4-way Hydraulic Valve

Hand and Pilot-operated Types for water or hydraulic oils to 5000 psi.

• These valves give users maximum efficiency, economy and dependability. Housings are milled from steel blocks or bronze forgings. The hollow, radially ported, stainless steel plungers are hard chrome plated and polished. Renewable metal valving rings assure long life of the packers which are expanded by internal pressure . . . the higher the pressure the tighter the seal. No metal to metal seating. The valves are fully balanced in any position. Inspection — and servicing if necessary — can be done easily *in the field,* avoiding the delays of returning valves to the factory for servicing, or the need to carry large inventories of standby valves — or even parts. Complete dimensions, capacities and other data sent promptly. Write for Bulletin No. 531,— Today!

Ask us also about . . .

CAM OPERATED SINGLE PLUNGER VALVE ⅜" to ¾" sizes. Operated by rotating cam or land on reciprocating device.



DOUBLE SOLENOID "O-TYPE" VALVE for pressures up to 125 psi. Widely used as pilot valves and for operating air cylinders.

Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1921 East Pershing St., Salem, Ohio

The result will be efficient, straight-line production through the plant from the original rod to the finished reels of wire rope ready for shipment.

WAGE HIKE TRIGGERS STEEL PRICE INCREASE

▲ Increases in wages and benefits that were provided for in the three-year labor agreement reached with the United Steelworkers of America last summer, took effect July 1.

This increase raises employment costs about 6 per cent, to an all-time high.

The total increases taking effect will amount to 21 cents per hour, including a cost-of-living adjustment of four cents per hour to take effect at the beginning of the first pay period on or after July 1. This compares with an increase of 24 cents per hour following the signing of the three-year labor agreement last August 3. Since then, however, there have been other contractual cost increases, including a cost-of-living increase of three cents per hour, which became effective last January under terms of the agreement.

The new pay adjustments will bring the average hourly employment cost for wage employees engaged in steel production to about $3.52 per hour, a record high.

To offset part of the increased cost, steel prices were raised about four per cent—approximately $6 per ton.

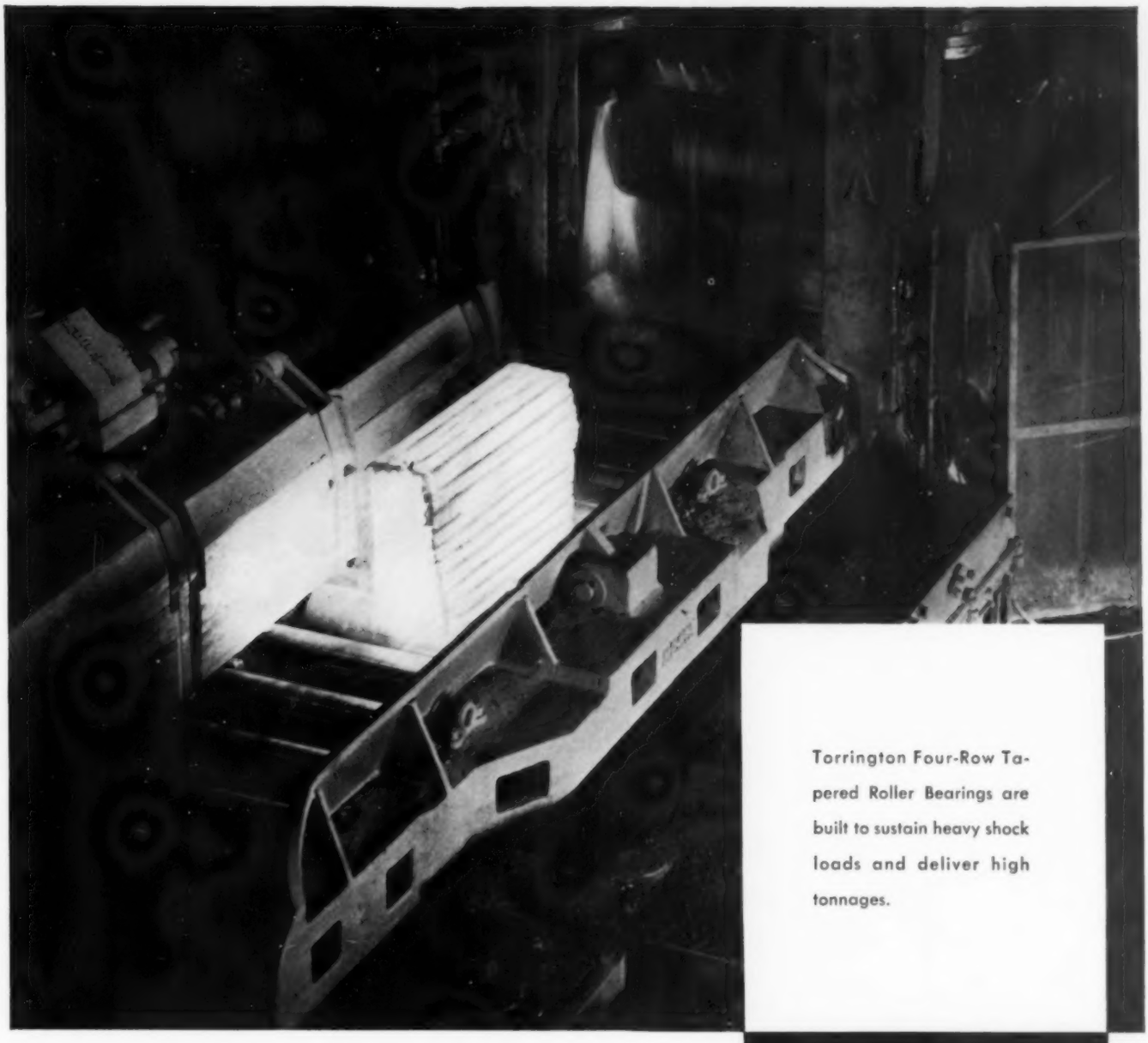
RELINED BLAST FURNACE IS BACK IN OPERATION

▲ The No. 2 blast furnace at the Aliquippa Works of Jones & Laughlin Steel Corp. was "blown in" June 12.

The furnace had been out of production since March 3 for relining and enlarging. During the period of shutdown, the hearth diameter was increased from the former 21 ft 6 in. to 28 ft 6 in.

This makes No. 2 equal in size to the two other largest blast furnaces of the five at the Aliquippa Works. It is able to produce 1270 tons of iron a day, an increase of 370 tons over its former capacity.

No. 2 was blown in over 20 years ago, on February 18, 1937, and the original "hearth and bosh" section never had been replaced. During this period, No. 2 furnace produced over 5,184,000 tons of iron.

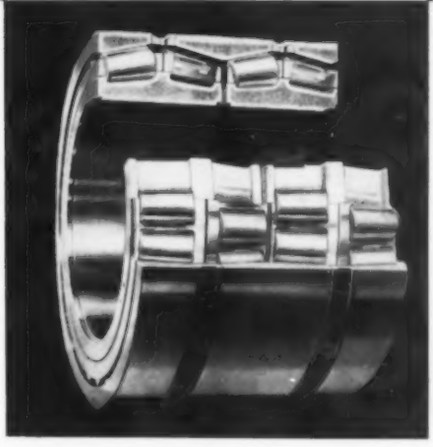


Torrington Four-Row Tapered Roller Bearings are built to sustain heavy shock loads and deliver high tonnages.

When the squeeze is on!

Under the pressure of high production schedules, Torrington Bearings handle heavy thrust and radial loads with reliability and stamina that mean *tonnage* with *economy*. Only the finest electric furnace steel is used in their construction. Races and rollers are carburized and heat-treated for toughness, stability, hardness and uniformity. Precision tolerances and finishes mean minimum friction, low eccentricity and uniform load distribution.

Torrington Work Roll Bearings come in many standard sizes in both two-row and four-row, with either pin-type or cast-bronze, land-riding cages. For handling any combination of radial and thrust loads, you can do it better with Torrington Bearings. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

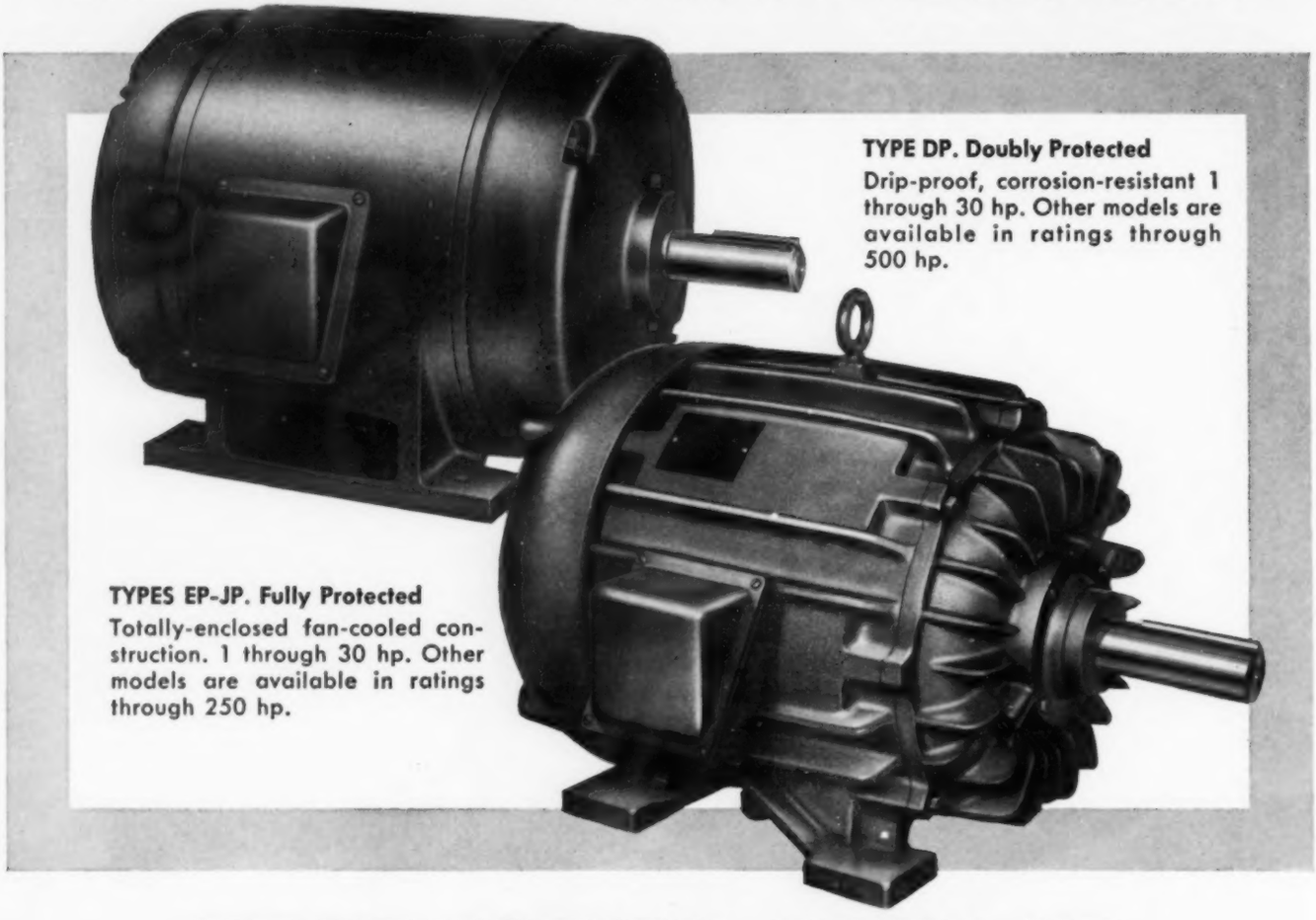


TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

TAPERED ROLLER • SPHERICAL ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

WAGNER ELECTRIC MOTORS...THE CHOICE OF LEADERS IN INDUSTRY



TYPE DP. Doubly Protected
Drip-proof, corrosion-resistant 1 through 30 hp. Other models are available in ratings through 500 hp.

TYPES EP-JP. Fully Protected
Totally-enclosed fan-cooled construction. 1 through 30 hp. Other models are available in ratings through 250 hp.

PRODUCTION GOES UP
when you power equipment with these Wagner Motors

Production is increased when motor down-time is reduced. To meet today's industrial demands for faster, more dependable production, Wagner has designed these industrial motors with *extra* protection that cuts time-out for motor maintenance to a minimum.

These motors pack more power in less space—1 through 30 horsepower in NEMA frame sizes 182 through 326 U.

EXTRA PROTECTION—Type DP is doubly protected by a rugged corrosion-resistant cast iron frame and by completely drip-proof enclosures.

Types EP and JP are totally enclosed against dust, grit, fumes or moisture—protected against corrosion by cast iron frames. Type JP is explosion proof as well.

COOL RUNNING—Both types are cool running. Blowers and special baffles direct cooling air through the DP motor. Types EP and JP are fan-cooled and are built with ribbed frames to increase the cooling surface.

LONGER BEARING LIFE—Original bearing lubrication will last for years in service under normal conditions, but openings are provided in the bearing housing to add fresh grease—remove old grease when required.

Let a Wagner motor application engineer show you how well these motors can fit *your* needs. Call the nearest of our 32 branch offices, or write us. Bulletins MU-202 and MU-203 give complete information on these Wagner Motors. Write for your file copies today.

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

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Wagner Electric Corporation
6483 Plymouth Ave., St. Louis 14, Mo., U.S.A.

M57-12

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

BEGINS EXPANSION OF STAINLESS FACILITIES

▲ A one million dollar expansion plan of its stainless steel sheet and strip facility at Washington, Pa., has been announced by Washington Steel Corp.

T. S. Fitch, president and chairman of the board, in outlining the project said, "We believe that stainless steel will continue to be a fast growing segment of the steel industry for at least another decade. This expenditure for improvement of plant facilities will place Washington Steel in a position to give better and faster service to our sheet and strip customers."

The expansion plan, which will be started immediately, includes enlargement of two of the shipping department buildings, plus a new carpenter shop building. Another major piece of production equipment will be a 48-in. wide continuous strip grinder. All three continuous strand annealing and pickling lines will be lengthened. Added flexibility of these lines will be achieved in that straight acid pickling, electrolytic pickling and Kolene salt bath pickling will be combined in one line, permitting a wide choice of cleaning methods. Thus the plant will be especially equipped to efficiently process all grades of stainless plus some other newer metals with minimum delay.

Other equipment to be installed includes a new roll grinder, air compressor, an 18-in. slitting line, resquare shears, and a new acid disposal plant.

NEW SULPHUR-REMOVAL PROCESS DEVELOPED

▲ Research on desulphurization of iron for Diamond Alkali Co., has resulted in the development of a new, continuous sulphur-removal process by Battelle Institute.

In the new process, molten iron and caustic soda are fed continuously into an apparatus where desulphurization occurs as the materials are intermixed. Desulphurized metal and caustic slag flow continuously from the apparatus into molds or ladles.

Introduction of a jet of oxygen into the mixing chamber makes it possible to remove substantial amounts of silicon at the same time the sulphur content is being reduced.

Under laboratory conditions, the new process has been used to achieve 90 per cent reductions in sulphur content, according to Battelle technologists N. H. Keyser and H. W. Lownie. Because of the low final sulphur content, the process holds promise for use in the production of ductile cast iron as well as in the desulphurization of pig iron prior to conversion into steel.

Desulphurization occurs rapidly because thin layers of reacting materials are used. Samples taken during heats at Battelle's pilot-plant laboratory show that the sulphur-removal reactions after addition of the caustic soda require less than a minute for completion. Thus, large quantities of iron can be treated in a unit requiring relatively small space.

Some desulphurization is already being practiced to maintain quality in certain iron and steel production.

ANNOUNCES EXPANSION AT AVONMORE PLANT

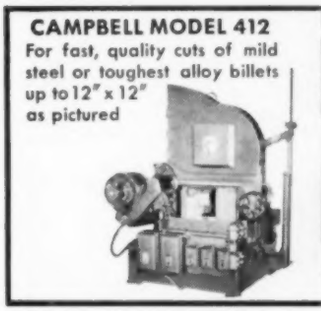
▲ The addition of a new manufacturing building at General Steel Castings Corp.'s National Roll & Foundry Division plant at Avonmore, Pa., has been announced. A new 20-ton electric furnace, heat treatment furnaces, pouring pit and other foundry facilities to be included in the new building will enable National Roll to cast steel rolls up to 35,000 lb in comparison with the

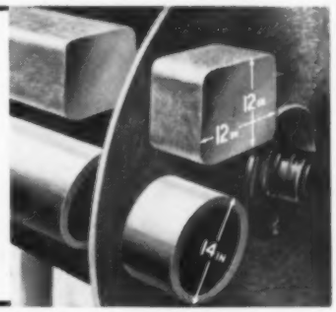
Campbell
Abrasive Cutting Machines

Abrasive Cutting Know-How

Know-How is just as vital to top performance in abrasive cutting as in any other machine tool operation

CAMPBELL MODEL 412
For fast, quality cuts of mild steel or toughest alloy billets up to 12" x 12" as pictured





Users of Campbell Abrasive Cutting Machines get Tremendous Savings with Fast, Accurate, Quality Cuts of Mild Steel or Toughest Alloys

Write us and we will gladly send you helpful information on the working capacities of the 16 models of CAMPBELL Machines and the CAMPBELL Operating Features that explain the outstanding performance of these machines in cutting a wide variety of shapes and sizes of stock—channels...bars and tubing from the smallest to 14" diameter ...plate up to 4" thick and 20 feet long ...billets up to 12" x 12".

CAMPBELL Machine performance is well illustrated by the **Model 412** pictured above. This machine cuts through 12" x 12" billets of mild steel or toughest alloys (even titanium) in the almost unbelievable time of 6 to 10 seconds per square inch...*with quality cuts.*

Here are some of the operating features that account for comparable speed and quality of cuts by CAMPBELL's 10 high speed production models...two of them fully automatic for highest production.

Oscillation of the Cutting Wheel to maintain cutting speeds and greatly lengthen wheel life is prescribed by CAMPBELL for all solids cuts over 2" in diameter.

Wet Cutting gives maximum assurance of Quality Cuts.

Ample Power, essential to good performance, is supplied for the Model 412 by a 40 HP motor.

Sound Work Holders — essential to accuracy.

For greatest abrasive cutting accuracy, CAMPBELL provides two oscillating machines that rotate the work—round bars or tubing from 3" to 14" diameter.

For further information write for the illustrated Bulletin DH-460-B

ACCO

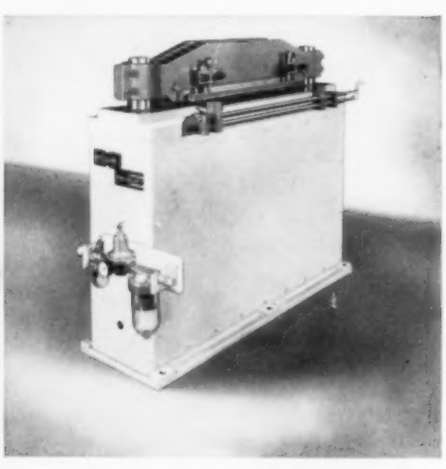
Campbell Machine Division • AMERICAN CHAIN & CABLE

928 Connecticut Avenue, Bridgeport 2, Connecticut

HERR EQUIPMENT

"Complete Processing and Handling Equipment . . . for any Ferrous or Non-Ferrous Material . . . That Starts — or Ends — as a Coil"

Fast, dependable method of fastening the lead end of a new coil to the trailing end of a preceding coil. Entirely automatic. Produces a double row of locked stitches. Practical for strip of any width. Your samples stitched and returned promptly. Also automatic welders.



Fast acting single shears for use with hump tables in cut-to-length and press feed lines, and other applications to square crop the end of a coil. Also twin cut shears that remove the section where two coils were stitched or welded together for continuous processing.

Write for fully descriptive Bulletin No. 561 today!

THE HERR EQUIPMENT CORPORATION

1270 VINE STREET • WARREN, OHIO

CLEVELAND, INDIANAPOLIS AND BERKELEY, CALIFORNIA

plant's present maximum steel roll size of 20,000 lb. The new facilities will also increase the Avonmore plant's monthly steel roll capacity from 150 to 400 tons.

The new building is the latest stage in an over-all $2,000,000 capital improvement and rehabilitation program at Avonmore, which will be completed by the end of 1957. Included in the program, and previously announced, are a quarter-million dollar roll grinder to accommodate rolls up to 45-in. in diameter and 60,000 lb in weight and a 50-in. by 300-in. engine lathe, both with automatic feed and latest safety devices. Extensive rehabilitation of both the iron and steel foundries and the roll shop are also included in the program.

U. S. STEEL OPENS NEW PROVO NITROGEN PLANT

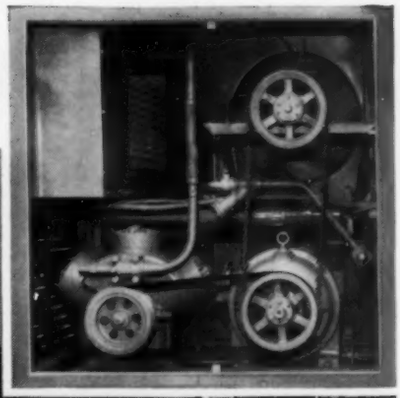
▲ The nitrogen plant at U. S. Steel Corp.'s Geneva Works, Provo, Utah, was officially opened June 28.

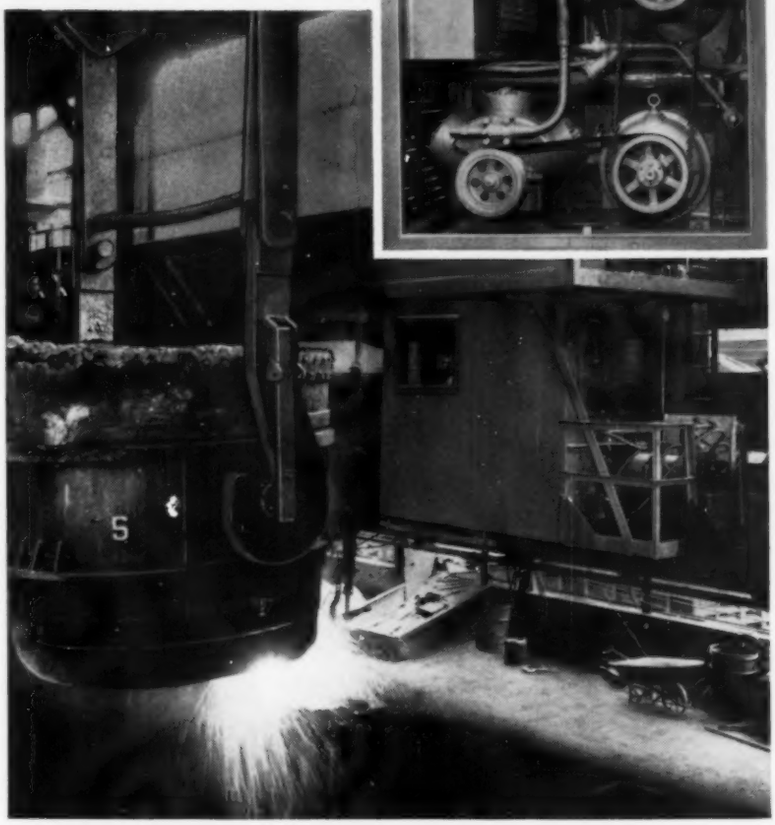
The installation utilizes several Montecatini processes in manufacturing anhydrous ammonia and in producing other nitrogen products from coke oven gas. The gas which comes from Geneva's 252 coke ovens is rich in hydrogen. This hydrogen is extracted from the gas and mixed with nitrogen which is separated from the air to produce the basic chemical building block, anhydrous ammonia, by the Montecatini synthesis process.

Anhydrous ammonia is stored in two giant Hortonspheres, each with a capacity of 2100 tons. This product, which contains 82 per cent nitrogen, is used primarily as a fertilizer. It also is used by other manufacturers of fertilizer for further processing. At the Geneva plant, some of the ammonia production is further refined into nitric acid. This is vital in the rare metals extraction industry.

A third product of the plant—ammonium nitrate—comes from the mixture of anhydrous ammonia with nitric acid. It is a high-strength fertilizer containing 33.5 per cent nitrogen. It is produced in the ammonium nitrate section of the new plant. Liquid ammonium nitrate is sprayed from the top of a 13-story tower and in the fall to the floor of the tower, solidifies into "prills" or small granules.

Condenser section of a 7½ hp unit. Note easy access to all components.





Productivity gets a lift from crane cabs that stay cool

Operator efficiency goes down when cab temperatures go up. That is why crane engineers demand crane cab conditioners that are dependable.

Dravo Crane Cab Conditioners *are* dependable because:

BASIC DESIGN—rugged construction and heavy duty components fit Dravo Conditioners for continuous service under the most severe operating conditions.

HIGH EFFICIENCY—low operating temperatures in condenser section, together with reduction of compressor head pressure step up unit efficiency.

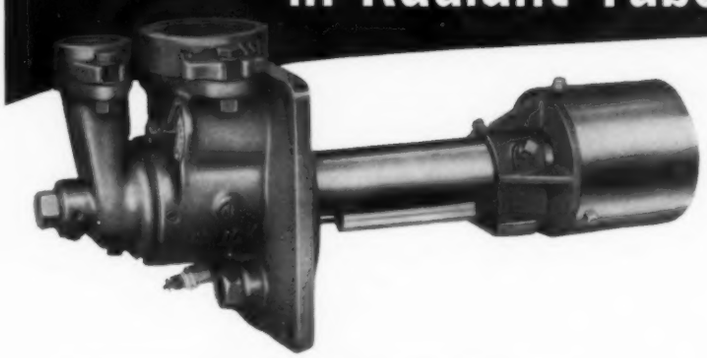
EASY MAINTENANCE—all components readily accessible. Inspection need not interfere with conditioner operation.

For information on Dravo Crane Cab Conditioners, write for Bulletin #1350-33, Dravo Corporation, Pittsburgh 22, Pennsylvania.

DRAVO
CORPORATION

DRAVO

You can get More Uniform Heat Distribution in Radiant Tube Firing with



HAUCK

Series RTG

Radiant Tube Gas Burners

featuring

- Flame length control
- Primary air adjustment for any industrial fuel gas
- Greater flexibility for application to various size tubes
- Turndown ratio 5 or 10 to 1
- Quieter operation
- Longer operation between burner cleanings
- Observation port for viewing flame
- Direct spark ignition—instant, quiet lighting
- No pilot required
- Air and gas connections are rotatable and flanged

Write for Catalog 808

performance!

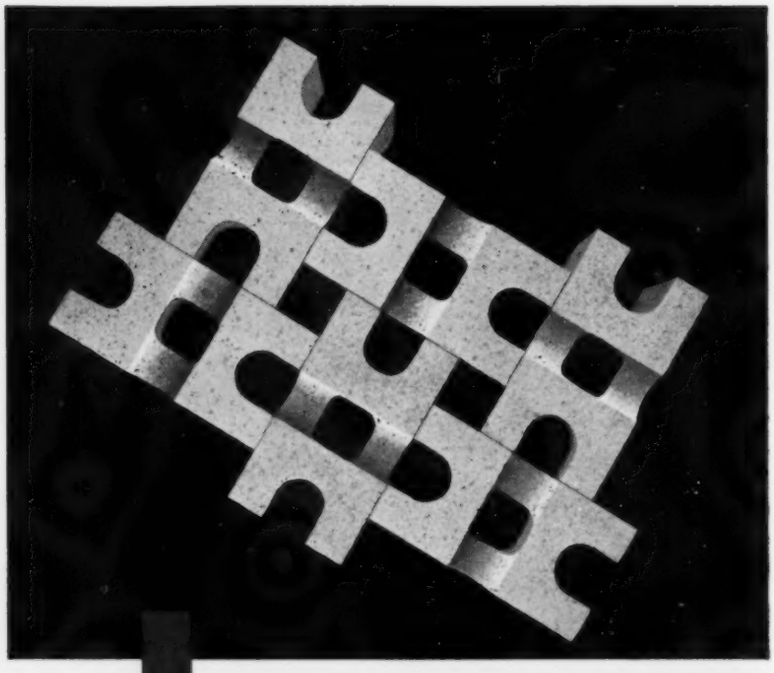
A steel plant reports that an annealing cover equipped with Hauck Series RTG Burners gave the highest anneal rate, and the best, entirely trouble-free performance ever experienced. . . . In another plant using unscrubbed coke oven gas, these burners have been in service from 100 to 124 heats before cleaning was necessary. Another make of burner regularly required cleaning after only 11 heats.

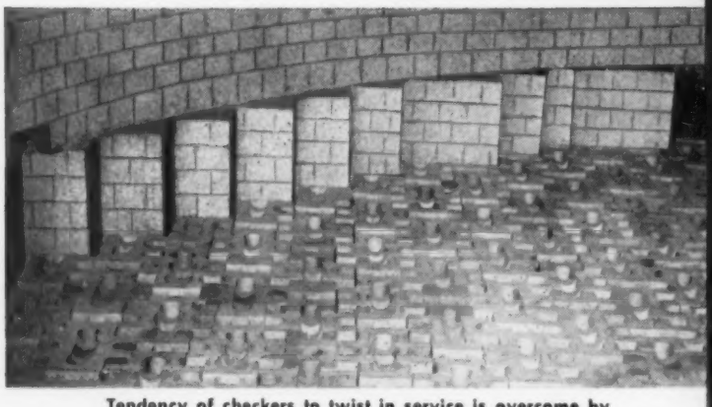
HAUCK MANUFACTURING CO.
114-124 Tenth Street—Brooklyn 15, N. Y.

New design provides

25% to 50% GREATER HEATING SURFACE

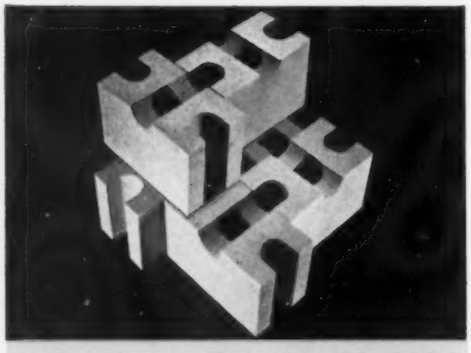
than ordinary basket weave checkers



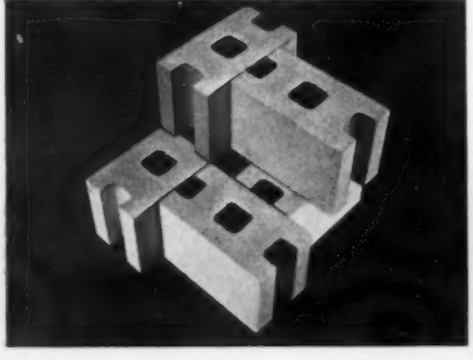


Tendency of checkers to twist in service is overcome by pilaster wall construction of the Bailey Hot Blast Stove.

KENNEDY
BLAST FURNACE STOVE
CHECKERS



The regular Kennedy Checker (above) is of 3-hole design with unobstructed flue openings, 1¼" minimum wall thickness and a cross flue. It also can be furnished (below) without the cross flue feature.



This new 3-hole checker shape is laid in basket weave style to produce a solid 1¼" wall between each flue. This assures greatly increased heating surface without sacrificing the advantages of basket weave design.

The increased heating surface of the Kennedy Checker results in a correspondingly lower stack temperature. This makes possible the use of a modern steel bottom for supporting the checker system.

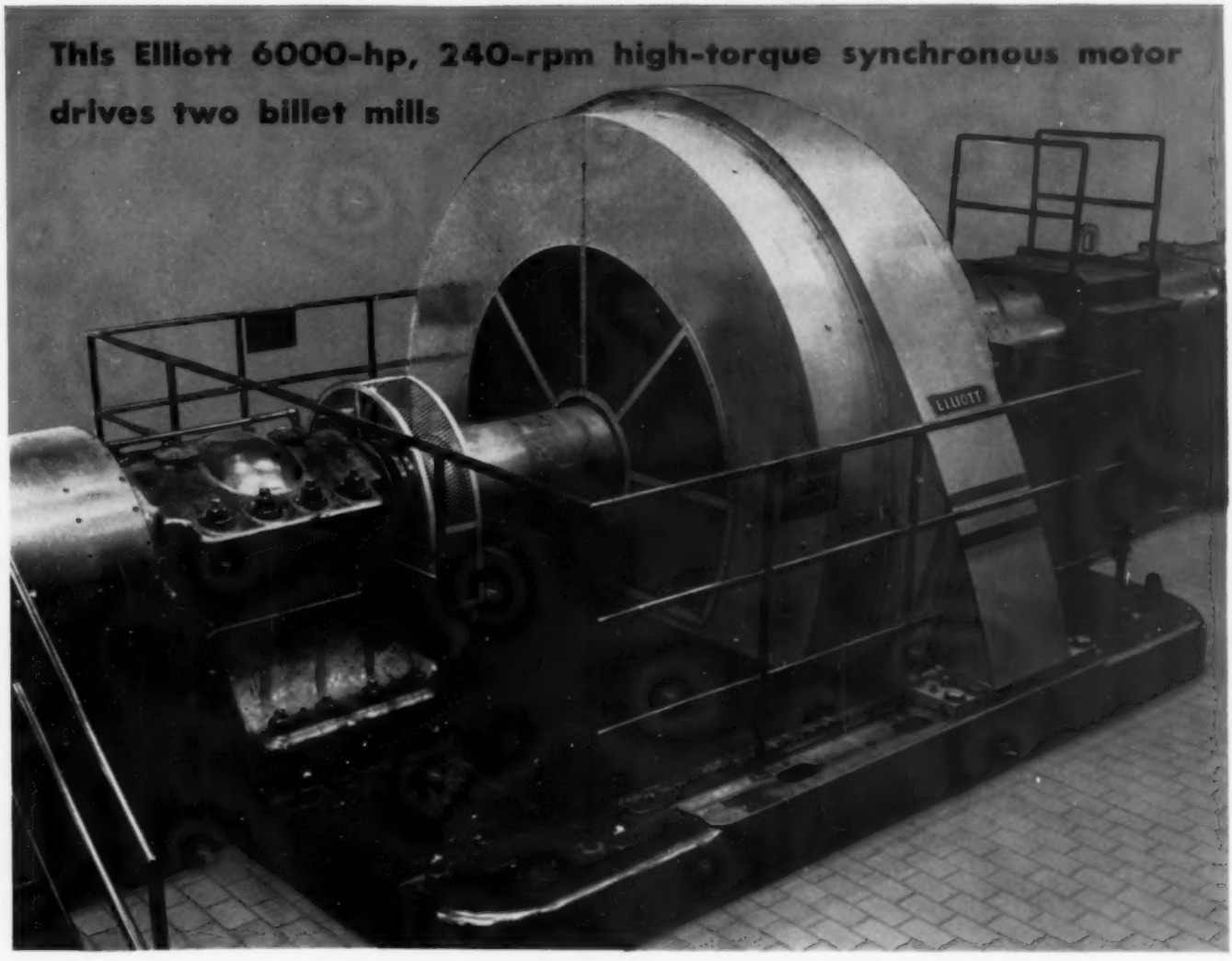
Write for Bulletin

WILLIAM M. **Bailey** COMPANY

ENGINEERS

LEADERSHIP THROUGH QUALITY

1221 BANKSVILLE ROAD PITTSBURGH 16, PA



Installed over the weekend—no lost production time

designed to fit existing bearings and base

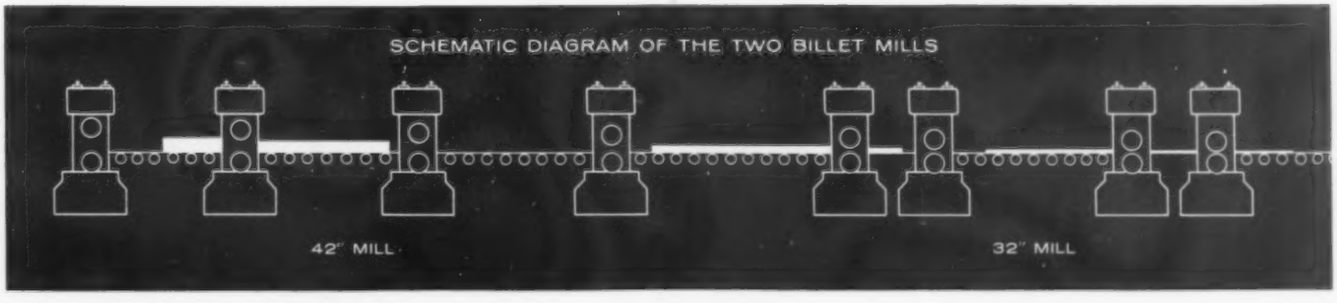
Come Monday morning, this Elliott 6000-hp high-torque synchronous motor was in operation. (On the previous Friday, power was still being furnished by an old wound-rotor motor.) The new Elliott motor drives, through gear trains, two billet mills, each containing four mill stands. The motor was engineered and built by Elliott to fit existing bearings and base, and the remarkably quick changeover reflects the excellence of Elliott engineering and workmanship.

Satisfactory experience with similar Elliott apparatus previously installed at this plant led to the selection of the Elliott motor for this billet mill drive.

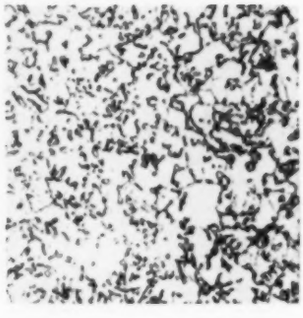
ELLIOTT Company

Ridgway Division, Ridgway, Penna.

R7-24



carbon-restored steel meets tightest specs



■ This steel mill easily meets the steadily tightened specifications of customers who demand stock with good surface finish, no "decarb," and uniform microstructures suitable for cold forming and automatic machining.

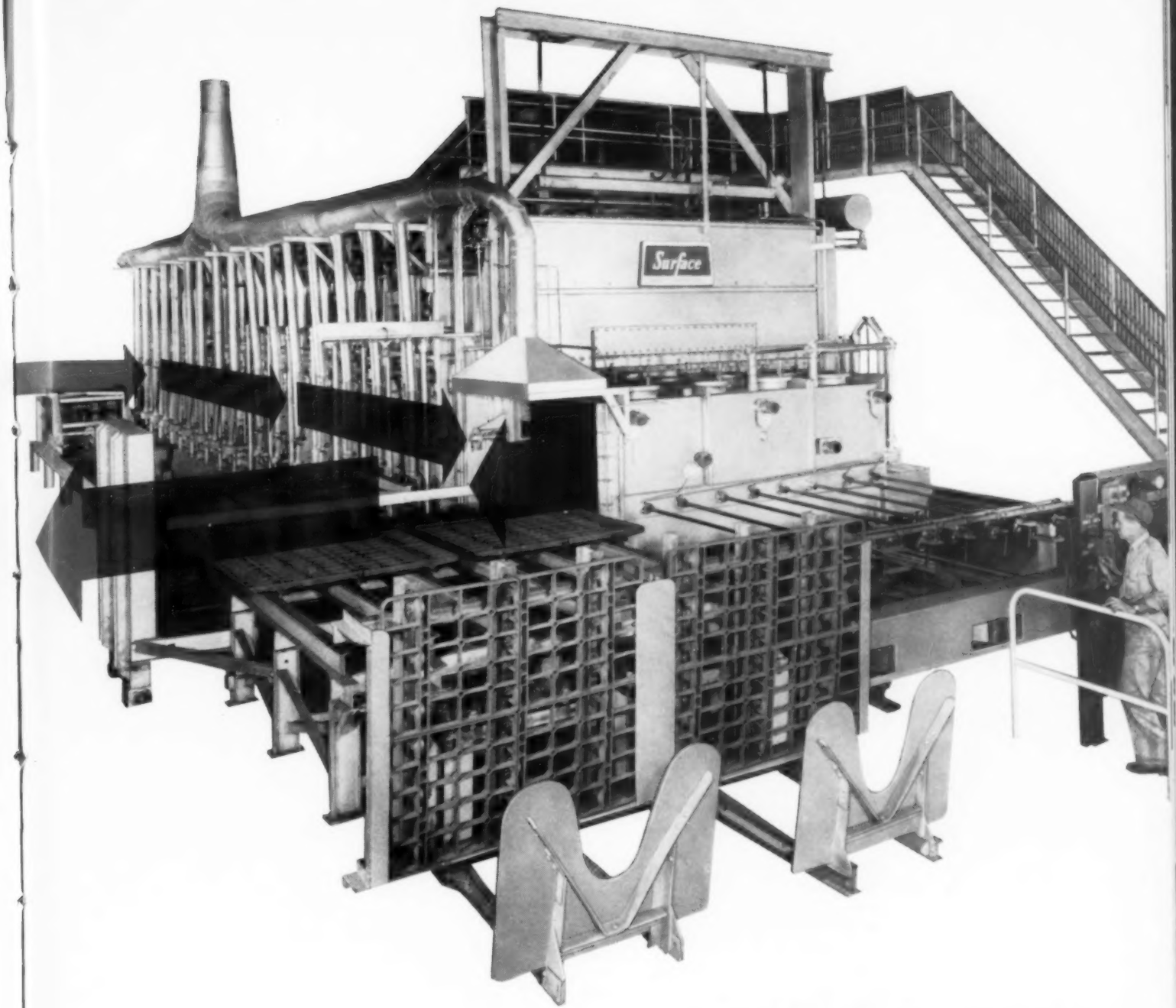
They do it by combining annealing and carbon restoration in a Surface continuous furnace. They get all the flexibility of cycle control they need with 6 zones, individually controlled. An RX® gas generator keeps the carbon potential of the furnace atmosphere in balance with the steels being treated. Automatic dew point recorders provide a continuous check on the atmosphere.

Production rates up to 1,000 tons per month make this furnace a profitable tool.

Again, Surface engineering transforms difficult specifications into profitable opportunities.

Surface Combustion Corporation, 2404 Dorr Street, Toledo 1, Ohio.
In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario.

ASSOCIATED COMPANIES: British Furnaces, Ltd., Chesterfield • Stein & Atkinson, Ltd., London • Stein & Roubaix, Paris • S. A. Belge, Stein &



you can meet these specifications:

CYCLE ONE (sub-critical anneal)		CYCLE TWO (over-critical anneal)	
STEEL (AISI)	MAXIMUM-BRINELL	STEEL (AISI)	MAXIMUM-BRINELL
4042	160	4037	151
4140	170	4140	174
5140	166	8127	148
8740	170	8740	174

Cycle One production must show spheroidized structure. Cycle Two must show lamellar pearlite structure. Brinell hardness after annealing.

wherever heat is used in industry

Surface®

Roubaix, Bressoux, Liege • S. A. Forni Stein, Genoa • Chugai Ro Kogyo Kaisha, Ltd., Osaka • Benno Schilde Maschinenbau, A. G., Bad Hersfeld

ALBERT SAUVEUR *was the first man in America to study steel through a microscope. In that way he noted the relative effects of temperature, amount of work, cooling rate and chemical composition on the grain size of both rolled and forged steels.*

From these studies, Dr. Sauveur was able to show that there was a certain critical temperature which, following hot work and slow cooling, yielded the smallest grain size. This brought immediate modifications in rolling and forging procedures which, until then, had been done at the highest possible heat.

Thus, in 1896, began researches into the working and heat treatment of steel which form the basis of our present knowledge of metallurgy. In almost every branch of this science, Albert Sauveur contributed useful and important knowledge. Harvard University describes him as "a founder of the science of metallography". For this, and his life's work as scientist, teacher and our first consulting metallurgist, his is a great name among steel makers.

Great Names in Steel Making #VI

The same day Albert Sauveur first focused his microscope on a specimen of steel, a mill employee on the Monongahela was busy paddling heavy grease on the roll necks of a small hand mill. The grease, a fatty base material having a high melting point, had recently been compounded by The Ironsides Company, of Columbus, Ohio. It was called "Shield" and performed so well that the name "Shield" in time, became synonymous with satisfactory lubricants.

The work of steel makers and lubrication engineers has come a long way since then — from small, slow mills, greased by hand with a paddle, to today's four and five stand continuous mills requiring automatically applied lubricants able to support sustained mill speeds of 4300 fpm and pressures as high as 25,000 psi.

In this progress, Ironsides specialists have "teamed" with mill superintendents, lubrication engineers and rollers to solve numerous problems. To achieve a satisfactory roller bearing Shield, for example, it was necessary to develop a pumpable, water repellent, extreme pressure lubricant that was also free-running in order to minimize the enormous power consumption of modern rolling mills. The even tougher problem of producing a domestic roll oil to replace imported palm oil was licked by the development of Palmoshield.

Ironsides engineers are equally accustomed to studying the problems of individual mills and compounding lubricants for specific conditions and preferences. These "custom tailored" lubricants are supplied in any quantity, from pails to tank cars.

Do you have such a problem—or an interest in improving present lubrication performance? A letter, or phone call, will bring one of our research engineers. The Ironsides Company, Columbus 16, Ohio.

Ironsides

By the makers of Palmoshield
"the palm tree that grows in Ohio"

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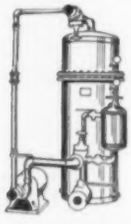
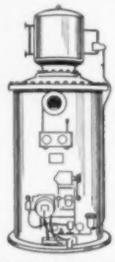
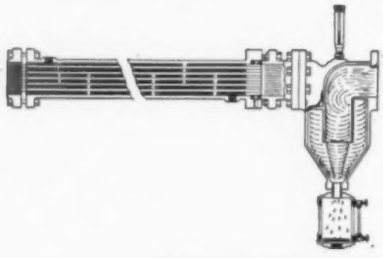
ADAMS HAS THE RIGHT EQUIPMENT TO SOLVE YOUR PROBLEMS IN:



Chemical Filtration



Industrial Water Filtration



Moisture Removal from Compressed Air and Gas Systems—

. . . and these men, part of the Adams sales representative team, are your assurance of prompt process design assistance. Why not take advantage of their help today?

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THE EUCLID ELECTRIC
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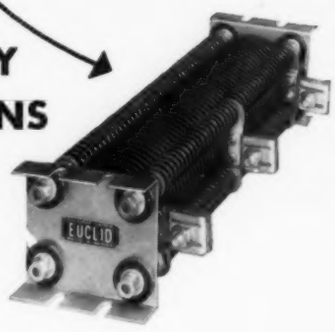
K·1 RESISTORS

FOR HEAVY-DUTY APPLICATIONS

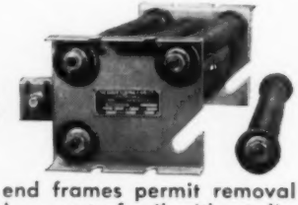


All Steel and Mica Construction provides a truly non-breakable resistor.

Continuous stainless steel edge-wound coil without joints eliminates hot spots, buckling and distortion.

Support rods on outside of coil permit unobstructed cooling air flow and compact design for smaller size and less weight per horsepower.

Exclusive slotted design



Slotted end frames permit removal and replacement of coil without disturbing rod assembly.

WRITE TODAY FOR BULLETIN 3004

THE EUCLID ELECTRIC & MFG. CO.
MADISON, OHIO

THE EUCLID ELECTRIC
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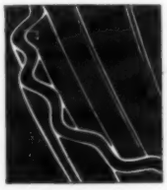
AND MFG. CO., MADISON, O.

Preparing a cinder pot pattern at Mack-Hemp's Midland Works

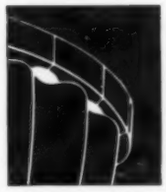
LONGER SERVICE FOR CINDER POTS STARTS HERE

Year after year for twenty years Mack-Hemp engineers have modified and improved the design of their Johnston *Corrugated* Cinder Pots. Each change has boosted service life another notch. Each has been enthusiastically accepted by open hearth and blast furnace operators. Today, thousands are used in leading steel plants. Our brochure gives you all the facts. Why not phone or write for one today? Mackintosh-Hemphill Division, E. W. Bliss Company, 901 Bingham Street, Pittsburgh 3, Pa.

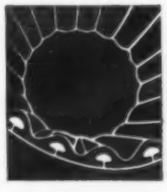
Each of these exclusive design features has added new life:



Corrugations speed heat dissipation and permit expansion and contraction without buckling or cracking of the walls.

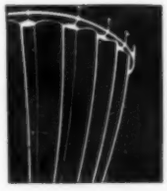


Expansible rim eliminates distortion of open diameter, maintaining proper fit of the pot in the trunnion ring.



Copper bottom coating—an optional feature—prevents "stickers" and makes dumping and skulling easier.

Short link supports lock pot in trunnion ring. Lugs cast near pot bottom reduce stresses in critical middle section.



Curved sidewalls prevent inward creep in the middle section without adding extra metal to slow heat dissipation.

Get All The Facts—write today for a free copy of our 20-page brochure on Johnston cinder pots.

MACKINTOSH-HEMPHILL

DIVISION OF E. W. BLISS COMPANY

Makers of the rolls with the Striped Red Wabblers

Pittsburgh and Midland, Pa.

CAST MILL ROLLS • JOHNSTON CINDER POTS • ROTARY TUBE STRAIGHTENERS • END-THRUST BEARINGS • HEAVY-DUTY LATHES • STEEL AND SPECIAL ALLOY CASTINGS

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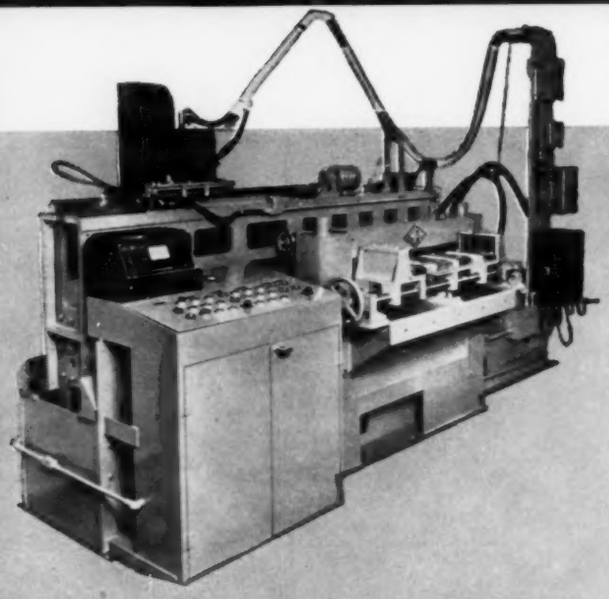
THE NEW MPM Shear Welder



CONTINUOUS SILICON SHEET PRODUCTION

Shearwelder for coil build up line for 42" wide Silicon Steel from .015" to .030" thick.

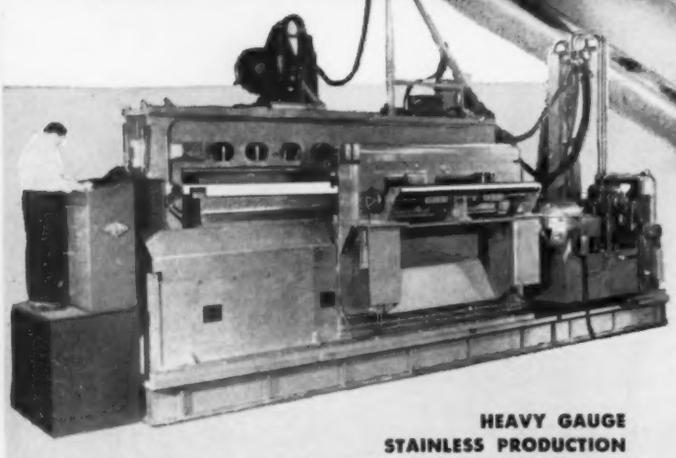
.....more automation for even faster Steel Production!

● Metal Processing Machine Company's new Shearwelders are outstanding because of their advanced design incorporating automatically sequenced operations.

Shearing and welding are performed at the same station with positive clamping right at the work area, thereby insuring perfectly aligned butt welds.

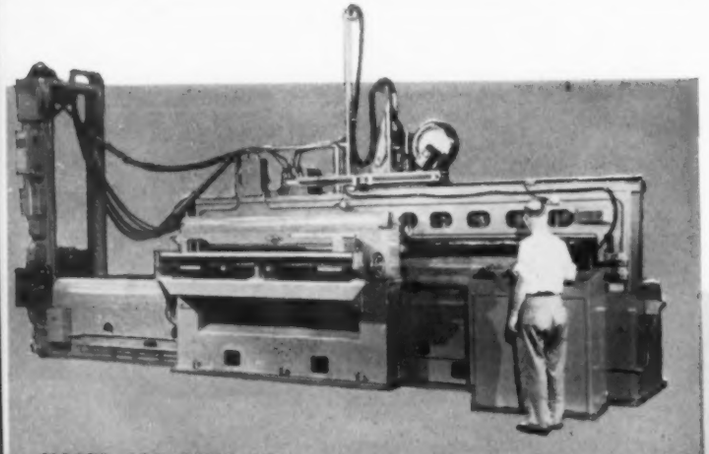
"M.P.M." welds are **extremely ductile,** permitting subsequent rolling, forming, or blanking operations. Weld joints are smooth and require **no trimming.**

Rugged construction is insurance for minimum maintenance and compact design saves floor space.



HEAVY GAUGE STAINLESS PRODUCTION

Shearwelder for butt welding 60" wide x .250" thick Stainless Steel.



MAJOR COIL BUILD UP

Shearwelder for Carbon Steel coil build up line for .015" to .060" thick x 72" maximum width.

THE METAL PROCESSING MACHINE CO.

SUBSIDIARY OF McKAY MACHINE CO.
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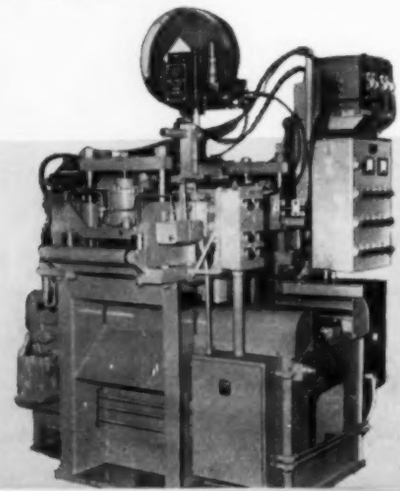


MPM

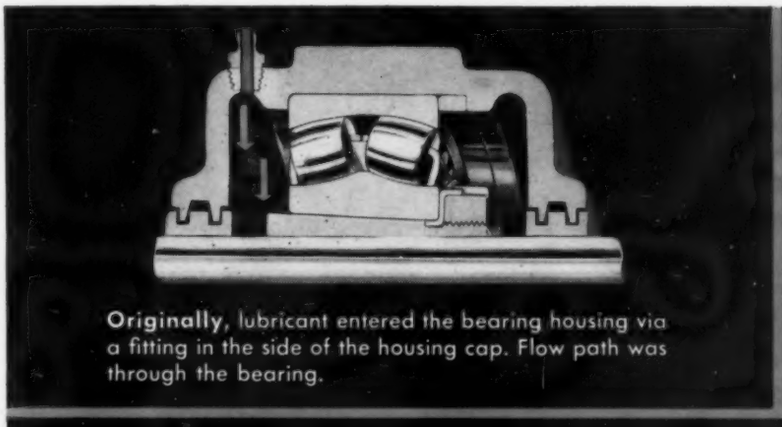
CONTINUOUS TUBE MILL PRODUCTION

Shearwelder used with strip looping device for splicing coil to coil to permit continuous production of tube mill.

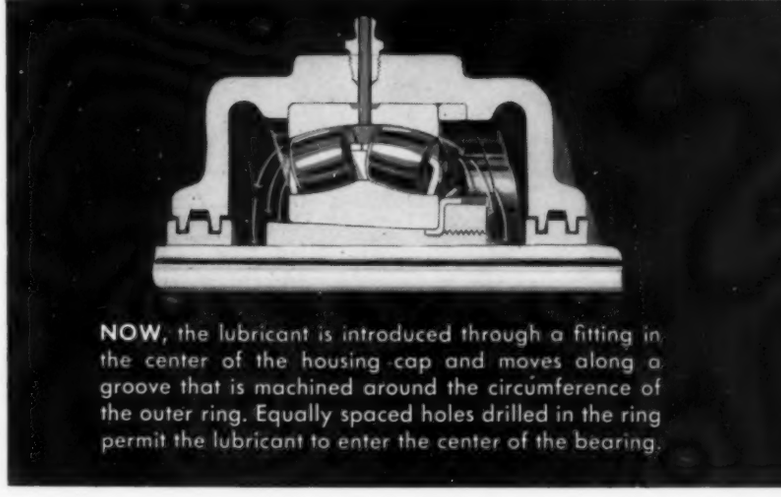
10065

At No Extra Charge ... A MAJOR IMPROVEMENT

IN LUBRICATING SPHERICAL ROLLER BEARINGS



Originally, lubricant entered the bearing housing via a fitting in the side of the housing cap. Flow path was through the bearing.



NOW, the lubricant is introduced through a fitting in the center of the housing cap and moves along a groove that is machined around the circumference of the outer ring. Equally spaced holes drilled in the ring permit the lubricant to enter the center of the bearing.

Nobody but SKF Offers This to You on Spherical Roller Bearings

Once again **SKF** offers another important innovation in spherical roller bearing design. Available in spherical roller bearings 140 mm (5.5118") O.D. and larger, this feature represents a still further improvement to the proven **SKF** Type "C" Spherical Roller Bearing.

The new design allows the lubricant to enter at the *center* of the bearing and move outwardly – completely covering all working surfaces. Old lubricant is flushed away from the bearing and, with it, any abrasive dust, dirt, moisture, or other impurities.

You can use this improved bearing in your existing housings simply by moving the lubrication fitting to the center.

Here again is an example of how **SKF** helps you to obtain longer bearing life, at no added cost. Send for Bulletin No. 443 for complete details. 7751

EVERY TYPE—EVERY USE

SKF®

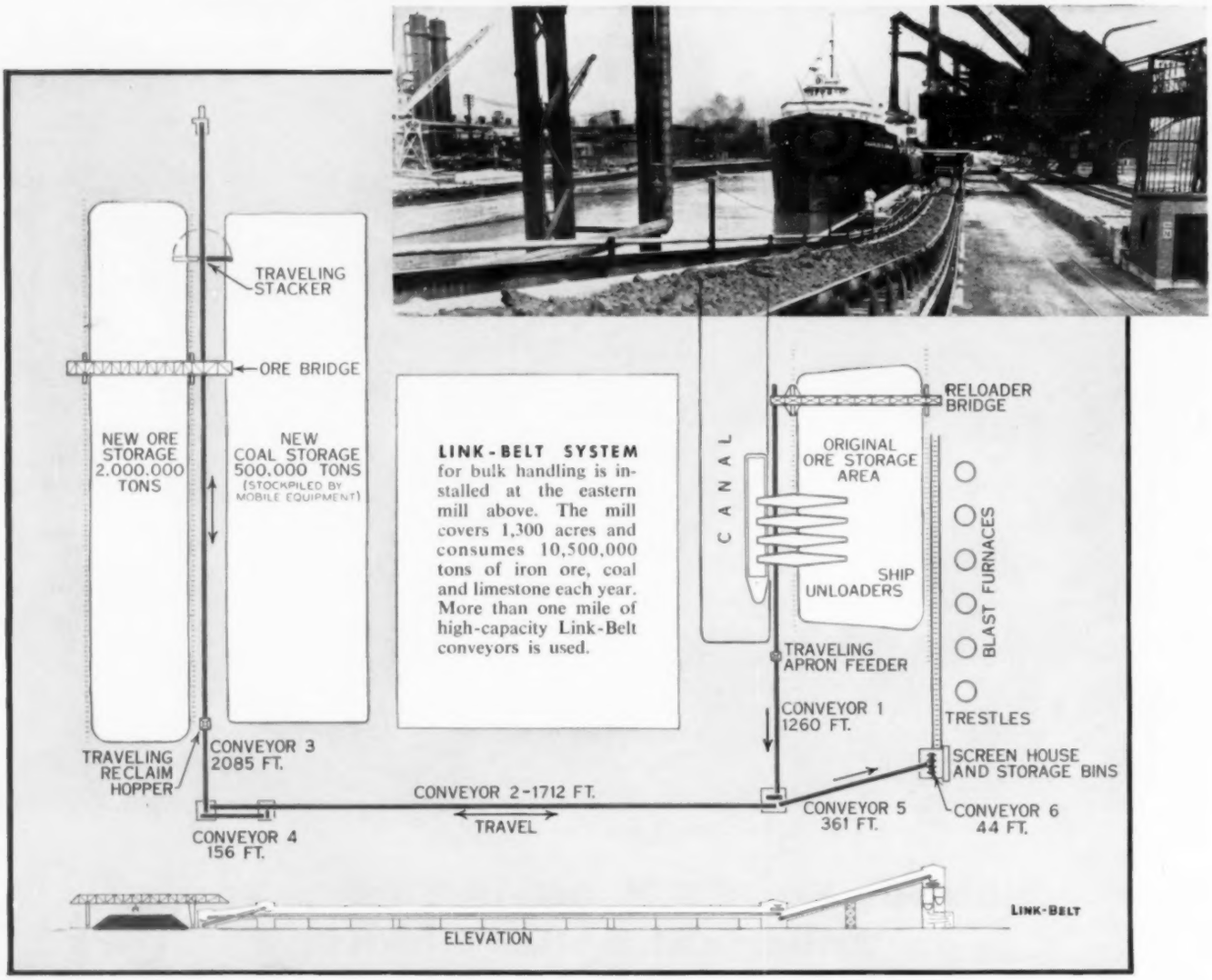
- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings ("Tyson")*

*Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

How LINK-BELT raw materials handling systems

keep pace with today's burdening techniques


TRAVELING STACKER
ORE BRIDGE
NEW ORE STORAGE 2,000,000 TONS
NEW COAL STORAGE 500,000 TONS (STOCKPILED BY MOBILE EQUIPMENT)
LINK-BELT SYSTEM for bulk handling is installed at the eastern mill above. The mill covers 1,300 acres and consumes 10,500,000 tons of iron ore, coal and limestone each year. More than one mile of high-capacity Link-Belt conveyors is used.
CANAL
RELOADER BRIDGE
ORIGINAL ORE STORAGE AREA
SHIP UNLOADERS
BLAST FURNACES
TRAVELING APRON FEEDER
CONVEYOR 1 1260 FT.
TRESTLES
SCREEN HOUSE AND STORAGE BINS
TRAVELING RECLAIM HOPPER
CONVEYOR 3 2085 FT.
CONVEYOR 2-1712 FT.
TRAVEL
CONVEYOR 4 156 FT.
CONVEYOR 5 361 FT.
CONVEYOR 6 44 FT.
ELEVATION
LINK-BELT

Meet the demands of greater blast furnace output with improved conveying efficiency

MODERN, more productive blast furnace burdening techniques—developed in answer to growing steel demand—have multiplied problems of storing and reclaiming bulk materials. Higher tonnages, more extensive storage areas, separate stockpiles for a greater number of individual ores—all increase the importance of integrated, high-capacity materials handling.

As one of industry's largest, most experienced conveying specialists, Link-Belt offers one source for engineering and equipping such systems for both new and expanding mills. Systems designed to make the most of existing space . . . handle increased capacities.

Our engineers are available to work with your own staff and consultants in mechanizing raw materials flow at your mill. Your nearest Link-Belt office will be glad to arrange a consultation at your convenience. 14,553

LINK-BELT

MATERIALS HANDLING, PROCESSING AND POWER TRANSMISSION MACHINERY

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

Personnel News...

William A. Steele has been appointed executive vice president of Wheeling Steel Corp., a position which has been vacant for several years. At the same time, **Paul W. Koenemund** was named to the position of vice president in charge of operations and engineering, succeeding Mr. Steele. He has been serving as chief engineer since 1955. Mr. Steele has been associated with Wheeling Steel since 1943 when he became general manager of the Benwood Works. Prior to that, he had been associated with Crucible Steel Co. of America at Midland, Pa., for 20 years. In 1950 he was put in charge of the Steubenville Works, and in 1955 was named vice president of operations. Mr. Koenemund became associated with Wheeling Steel in 1936 as assistant master mechanic at the Benwood Works. In 1941, he was made chief estimator and, in 1946 became plant engineer.

Charles P. Hammond, formerly general superintendent of mills for Northeastern Steel Corp., has been appointed assistant to the vice president in charge of operations, A. M. Byers Co. Mr. Hammond became associated with the steel industry as a roller with the Midvale Steel Co. in 1913. He later served in the same capacity with the Hess Steel Corp., now the Rustless Iron Corp., and with United Alloy Steel Co., now the Republic Steel Corp. In 1925 he joined Crucible Steel Co. of America as superintendent of mills at its Park Works, Pittsburgh, and in 1929 at the company's Atha Works. Mr. Hammond served with Atlas Steels, Ltd., Welland, Ontario, Canada, in 1933 as superintendent of mills and, from 1948 to 1951, was affiliated with the Rotary Electric Steel Co., as general superintendent of mills. In 1951 he was appointed general superintendent of the Green River Steel Corp., and since 1955 has served as consultant and general superintendent of mills for Northeastern Steel Corp.

B. Chandler Huselton has been promoted to assistant to the manager of the Butler Works of Armco Steel Corp. Mr. Huselton was formerly general foreman in charge of thin gage production at the Butler plant. He joined Armco at Butler in 1933. Shortly after becoming associated with the company, Mr. Huselton was transferred to the scheduling department. In 1946, he was promoted to assistant supervisor and in 1951, he became general foreman in charge of thin gage production.

A. S. Marvin has been appointed chief engineer, American Bridge Division, United States Steel Corp. He succeeds **C. E. Webb** who has retired. Mr. Marvin began his U. S. Steel service with American Bridge Division in 1924 at its Gary, Ind., plant as a draftsman. In 1940 he became a designer in the division's Chicago engineering department, and seven years later was appointed assistant division engineer at the Pittsburgh engineering department. The following year he was named division engineer and in March, 1955, appointed assistant chief engineer—contracts, the position he held prior to his new appointment.

Howard A. Winkler, supervisor of power at the Buffalo, N. Y., plant of Republic Steel Corp., has been appointed assistant to the superintendent of the electrical department. He joined Republic as a fuel attendant in 1949, and was named supervisor of power in 1953.

John H. Froelich has been appointed to the position of manager-production control for Universal-Cyclops Steel Corp. Mr. Froelich has been with the company for 22 years.

Harold Hoekelman has been appointed manager of the Chicago district of the Youngstown Sheet and Tube Co., succeeding **A. J. Cochrane** who was named assistant to vice president at the same time. Mr. Hoekelman joined Youngstown Sheet and Tube on January 1, 1956, as assistant manager of the Chicago district after 19 years as assistant and superintendent of maintenance of Republic Steel Corp. facilities in Youngstown. Mr. Cochrane began his career in the steel industry as a machinist helper for the American Steel and Wire Co. during summer vacations, advancing to the post of assistant to the general master mechanic of that company. He joined Youngstown as assistant manager of the Chicago district, on May 1, 1951, becoming Chicago district manager on May 1, 1954.

Robert D. Graham has been named superintendent of the cold strip mill at Crucible Steel Co. of America's Midland Works. He succeeds **Alex A. DeBlander,** who resigned. **Harold Kazen** has been named to succeed Mr. Graham as assistant superintendent of the cold strip mill. Mr. Graham joined Crucible in 1937 at Midland as a machinist. He became general foreman of mechan-

W. A. STEELE

P. W. KOENEMUND

C. P. HAMMOND

B. C. HUSELTON

P. L. McKEEVER

W. B. BROWNING, JR.

H. N. HUBBARD

W. L. FADER

ical maintenance of the cold strip mill in 1949, and in 1952 was made general foreman of cold rolling. He was appointed assistant superintendent of the cold strip mill in 1955. Mr. Kazen came to Crucible from Acme Steel Co., where he was employed for 22 years. His last position there was that of foreman in the cold roll department.

Paul L. McKeever has been appointed assistant works engineer—operations, Butler, Pa., Works, Armco Steel Corp. **Ward B. Browning, Jr.,** also has been named assistant works engineer—development and construction for the same plant. Mr. McKeever was formerly supervisor of electrical engineering for Armco. He joined the company in 1935 as an engineering draftsman. He was promoted to senior electrical engineer in 1942 and supervisor of electrical engineering in 1955. Mr. Browning joined Armco in 1946. He served as an engineering draftsman until 1951 when he was made senior electrical engineer. In 1956, he was made project engineer of the Butler Works construction program.

Howard N. Hubbard was appointed assistant general superintendent of National Works, National Tube Division, U. S. Steel Corp. He succeeds **William L. Fader** who was transferred to a similar position at the division's Lorain, Ohio, Works.

Mr. Hubbard joined National Tube as a student engineer at Lorain, later becoming a practice man in the open hearth, metallurgical melter foreman, and in 1941 assistant superintendent of the open hearth and foundry. In 1952 he was named assistant to the general superintendent and two years later was made division superintendent of the entire steel works operations. On January 1 of this year he was appointed assistant general superintendent at Lorain. Mr. Fader joined National Tube in 1950 at Christy Park Works and upon the death of the late **Arthur C. Landis,** succeeded him as general superintendent there. In 1954, he was transferred to National Works as assistant general superintendent.

John J. Hopper has been appointed assistant general superintendent of Ellwood Works of U. S. Steel Corp.'s National Tube Division. Mr. Hopper succeeds **H. D. Cunningham** who has been on an extended sick leave. Mr. Hopper began his business career as a student engineer at Ellwood Works in the spring of 1949. He was made foreman of the bar mill millwrights in 1950 and progressed through various positions in the mechanical maintenance department, becoming superintendent of that department, August 1, 1952, a position he has held until his present appointment.

J. J. HOPPER

Juan Zapata has been appointed vice president and representative in the United States for Compania De Acero Del Pacifico S. A.

Glen H. Rearick, member of the vice president's staff and former manager of two plants of The Babcock & Wilcox Co.'s Tubular Products Division, retired June 1. Mr. Rearick started with B & W in 1916 at the Barberton, Ohio, plant in the Boiler Division. Later he worked at the company's Bayonne, N. J., plant, and in 1918 was transferred to Beaver Falls. In 1921 he became superintendent of the cold draw department, and in 1939 was made superintendent of the hot finish department. A year later, he was placed in charge of building and operating the East Works department. In 1942, Mr. Rearick became responsible for the construction and operation of the Keystone Street plant in Alliance, Ohio. While superintendent there, he was appointed to take over the Milwaukee, Wisc., plant on its acquisition

Typically Vaughn—

THIS MIGHTY BRIDGE IS SUSPENDED BY Wire

Michigan's Mackinac Bridge—world's longest of its kind. Length of main span, 3,800 ft. Length of suspension bridge, 8,614 ft. Number of main cables, 2. Diameter of cables, 24½ in. Number of wires in each cable, 12,876. Total length of cable wire, 41,200 miles.

Installation Photo—
Courtesy American Steel & Wire Division United States Steel Corp.

DRAWN FROM THIS SINGLE Vaughn® MOTOBLOX®

All of the wire for the suspension cables of the Mackinac Bridge—41,200 miles of it—was produced on *one* Vaughn HRX Motoblox. Finishing the 0.192 diameter wire at higher speed and efficiency than ever before attained, the HRX machine employed to the fullest extent its outstanding power and cooling capacities. • *For profitable solutions to your own wire drawing requirements, consult VAUGHN!*

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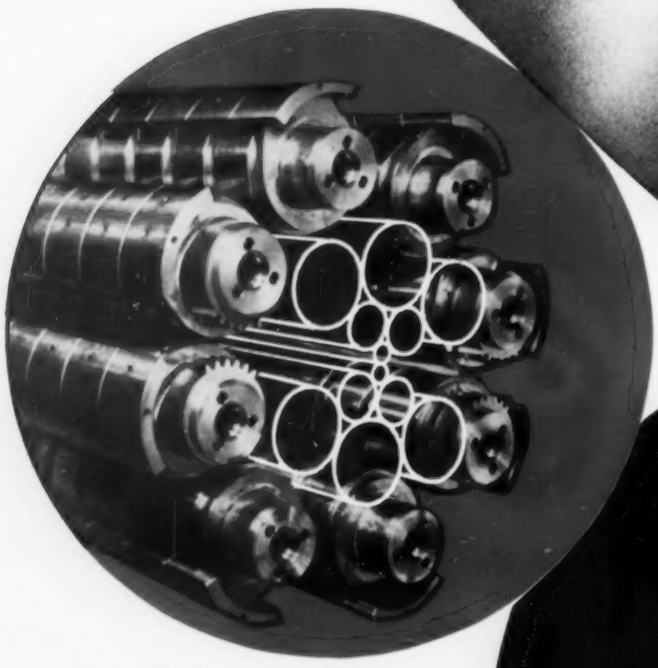
"Quick on the Draw!" Ⓥ®

This 80" SENDZIMIR MILL

maintains precise gauge across the width and along length of strip



Phantom view of roll arrangement

This Sendzimir cold strip mill rolls 80" wide low carbon steel from hot rolled thickness to .024" with total gauge variation of .0004". Similar uniformity is being regularly obtained on Sendzimir cold strip mills rolling brass, copper, aluminum, stainless steel, silicon steel, etc.

CONSIDER THE ADVANTAGES OF THE SENDZIMIR COLD MILL

- Extreme Accuracy In Gauge, Due To Uniform Support Throughout Mill
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- Highest Surface Finish
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Backing Roll Support

Sendzimir Support

WF-38

by B & W in January, 1955. The next year, he was appointed a member of the vice president's staff for special projects.

Joseph J. Hiegel, formerly chief electrical engineer for E. W. Bliss Co.'s Rolling Mill Division, has been appointed the division's assistant chief engineer. Mr. Hiegel has been with Bliss for seven years, specializing in the electrical aspects of rolling mill design. He was formerly assistant district electrical engineer for Republic Steel Corp.'s Warren, Ohio, District.

A. J. Winchester has joined E. W. Bliss Co. as chief electrical engineer of the Rolling Mill Division. Since 1941 he had been associated with Westinghouse Electric Corp., in its Control Engineering Department and in the Industry Engineering Department of the Steel Mill Section.

A. L. Lind has been appointed chief draftsman of the Rolling Mill Division, E. W. Bliss Co. Mr. Lind joined Bliss in 1949 as a mill erection engineer, and worked on various domestic assignments as well as foreign assignments in Europe, Japan and Brazil. Before this present assignment, he had been promoted to project engineer of the Rolling Mill Division in September, 1956.

Eugene Caldwell has been elected president of the Baker-Raulang Co. He was formerly vice president and general manager of the Hyster Co. Mr. Caldwell succeeds **Percy L. Douglas,** who continues as a director of Baker-Raulang and executive vice president of Baker's parent company, Otis Elevator Co.

Morris S. Lindsey has been appointed sales manager of the Mexico Refractories Co. of Texas, successors to Royall Fire Brick & Supply Co.

Niels K. Steenhill has been named a project manager of The Rust Engineering Co. He will be in charge of a steel expansion project for the Bethlehem Pacific Coast Steel Corp. at Seattle, Wash. For the past five years Mr. Steenhill was general superintendent of construction. He joined Rust in 1940 as a field engineer. In 1942 he was made a field superintendent and assigned to various construction jobs throughout the country during the following ten years.

Thomas L. English was promoted to general superintendent of construction for The Rust Engineering Co. He was formerly assistant general superintendent for three years and succeeds **N. K. Steenhill.** Mr. English has been a field superintendent for Rust Engineering and started in 1940 as a field engineer.

Dr. W. H. Jukkola has been appointed supervisor —chemical services section for Jones & Laughlin Steel Corp. He has been with J & L since 1939, when he started at the Aliquippa Works as Assistant chief chemist. He was named senior development engineer —chemical services in January, 1957.

E. A. Carlson has been appointed to the new position of administrative assistant to the vice president of The Ramtite Co. Previously Mr. Carlson was associated with the company's New England distributor, The Eastern Refractories Co., Inc., in the sales and service departments.

Dewey A. White and **J. G. Wicks** were appointed regional sales managers of The Okonite Co. Mr. White, district manager of the company's Birmingham, Ala., district since 1941, will now supervise the activities of the Birmingham, New Orleans and Dallas districts. The Philadelphia, Boston, Cincinnati, Syracuse, Detroit, Cleveland and Pittsburgh offices will report to Mr. Wicks, who has been Philadelphia district manager since 1954.

K. T. Bridgman has been named manager of the Bailey Meter Co.'s, Schenectady, N. Y., district office. He succeeds **J. F. Luhrs** who has been assigned to the Cleveland main office. Mr. Bridgman, formerly resident engineer in Springfield, Mass., joined the company in 1926.

Howard E. Morison was named as vice president of the Ingersoll Steel Division of Borg-Warner Corp. He comes to Borg-Warner from Crucible Steel Co. of America with which he has been associated in various executive capacities for the last seven years. During that time he was manager of the Agricultural Division, manager of the Alloy and Carbon Specialties Division, and product Sales Manager of the Silicon Steel Division. Previously he was with Owens-Corning Fiberglas

J. J. HIEGEL

A. J. WINCHESTER

A. L. LIND

EUGENE CALDWELL

R. F. STEWART

J. D. CAMPBELL

D. W. SHOEMAKER

J. L. MONTGOMERY

Corp. for five years and United States Steel Corp. for 16 years, serving in the Chicago, Milwaukee and Pittsburgh offices.

R. F. Stewart was elected a vice president of Western Precipitation Corp. Mr. Stewart joined Western Precipitation in 1946. He served as a sales engineer in the company's New York offices until 1951 when he was assigned to the Los Angeles offices as assistant chief estimator. Later he was named chief contract engineer, and in 1955 assumed the position of sales manager of the organization's Precipitator Sales Division.

James D. Campbell was appointed executive vice president of Patterson-Emerson-Comstock Overseas, Inc. Mr. Campbell was first employed by the General Electric Co. where, in addition to being located at the G. E. Steel Mill Division in Schenectady, he also served with G. E. International Co. in Japan on construction supervision. He later was employed by Mesta Machine Co., where, he was active as project construction manager of the Vanderbijl Park Works of Iscor (South Africa).

Donald W. Shoemaker has been named manager of manufacturing for Corhart Refractories Co., Inc. Mr. Shoemaker was formerly manager of the Corning Glass Works Refractories Plant at Corning, N. Y.

J. L. Montgomery has been named assistant manager of the Steel Plants Equipment Department of Blaw-Knox Co. He succeds **R. B. Groetzinger** who has retired after 43 years of service. Mr. Montgomery, who joined Blaw-Knox as a sales engineer in 1955, was formerly with the Quigley Co.

Walter Taylor has been appointed ceramic engineer at the Thomas Works, Delta-Star Electric Division, H. K. Porter Co., Inc. Mr. Taylor was formerly connected with Lapp Insulator Co.

Earl C. Jex, Jr., has been appointed sales engineer in charge of the newly established sales office of the Metal Products Division, Koppers Co., Inc., at Cincinnati, Ohio. Prior to joining Koppers, Mr. Jex was employed in various sales engineering capacities by the New Departure Division of General Motors Corp., and by Minnesota Mining and Manufacturing Co., and Hy-Pro Tool Co.

John H. Greenaway, Jr. was promoted to manager of operations for all plants of Johnson Steel & Wire Co., Inc., subsidiary of Pittsburgh Steel Co. Mr. Greenaway formerly was works manager at Johnson Steel & Wire's headquarters plant in Worcester, Mass.

Dr. Louis A. Carapella was named technical director of Jessop Steel Co. and subsidiaries, and **Elmer Ghrist** was promoted to general superintendent of Jessop from his former post as director of research and metallurgy.

R. L. Williams was named to the position of assistant chief engineer of the Automotive Division of the Timken Roller Bearing Co. Mr. Williams, who was formerly district sales manager for Timken's Industrial Division in Columbus, Ohio, started with the company in 1938 as a sales trainee, serving first in the Cleveland office, and then in the St. Thomas, Ontario office where he was made a district sales manager. He assumed his post as Columbus district manager of the Industrial Division in 1955.

John F. Rittenhouse, executive vice president since 1953, has been named president of C & D Batteries, Inc. He fills the post left vacant by the recent death of **Leon A. Doughty,** former president and one of the two original founders of the company. **Frank S. Carlile** was elected to the newly created post of chairman of the board. He had been vice president and treasurer of the firm.

Carl F. Henzelman has been promoted from open hearth superintendent to assistant superintendent of the Hot Metals Division of the Granite City Steel Co. **Arthur L. Howard,** who has been assistant open hearth superintendent, succeeds Mr. Henzelman as superintendent of that department. Mr. Henzelman, came to Granite City in 1952 as open hearth superintendent, after 30 years with the Bethlehem Steel Co. Mr. Howard has been with Granite City for 23 years, beginning as a 'door-puller" in the Open Hearth Department. He became an assistant melter foreman in 1943 and assistant superintendent of the department in 1950.

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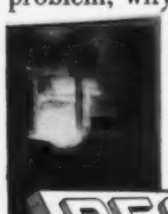

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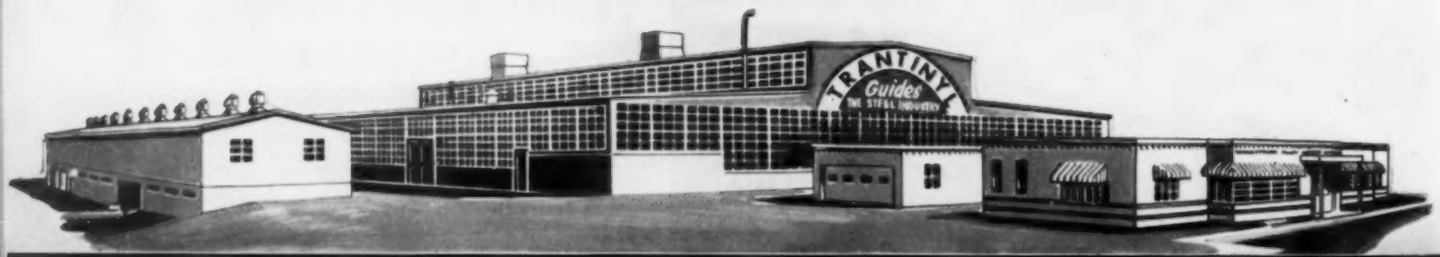

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Obituaries

Ernest T. Weir, former chief executive of National Steel Corp., died June 26. He began his career as an office boy for the Braddock Wire Co. in 1891. Later he worked at the Oliver Wire Co. and the Monongahela Tin

ERNEST T. WEIR

Plate Mills. In 1905 he joined the Phillips Sheet & Tin Plate Co. as general manager. Shortly thereafter, he became chief executive officer of the firm, which became Weirton Steel Co. in 1918. In 1929 he negotiated a merger agreement with M. A. Hanna Co. to form National Steel Corp. Mr. Weir retired as chairman of National Steel Corp. last April 24.

Irving W. Reynolds, 77, vice president of The Foxboro Co., died June 3. Mr. Reynolds came to Foxboro in 1908, the year the company was founded.

George J. Ehrhardt, chief engineer of the Clamshell Bucket Department, Blaw-Knox Co., died June 4. Mr. Ehrhardt, one of the pioneers in the design of the modern clamshell bucket, was 62.

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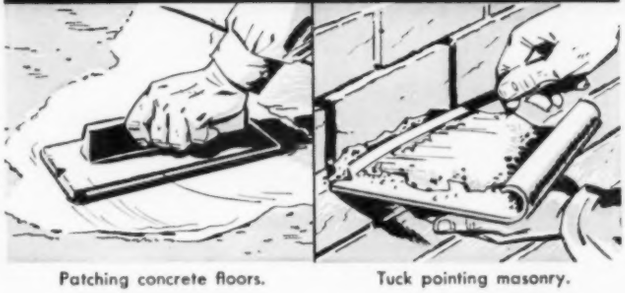
Have Lasting Concrete Repairs



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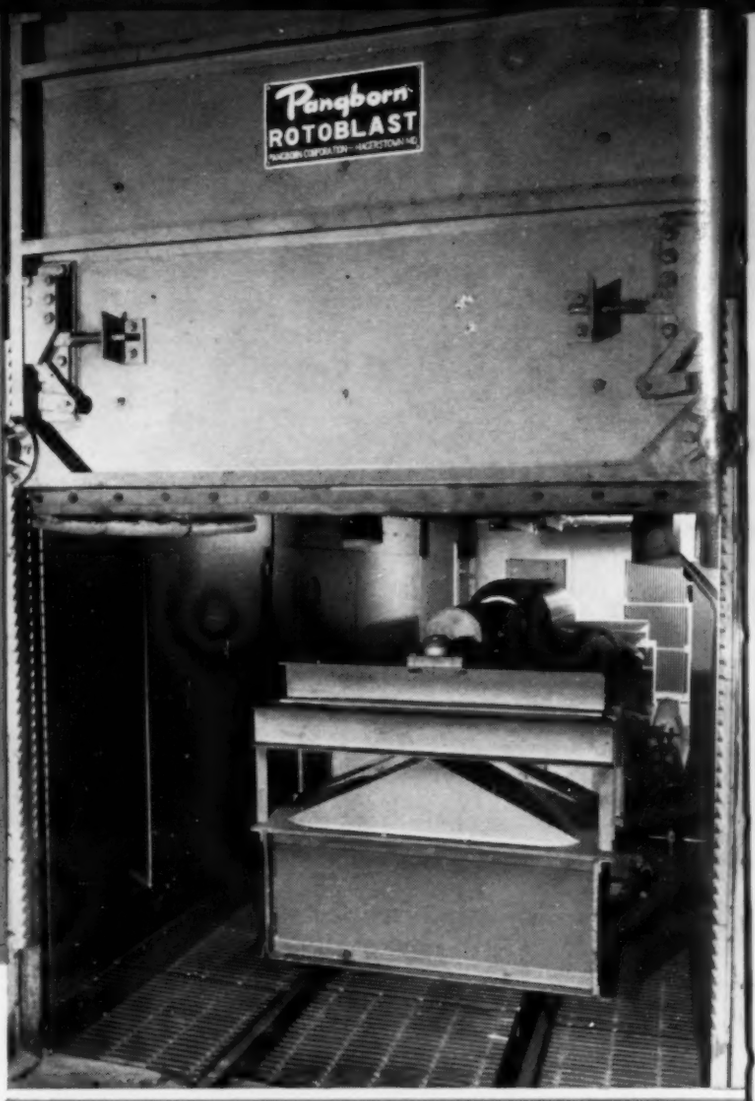
Mill rolls etched twice as fast with Pangborn Rotoblast®



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Write today for Bulletin 610 to PANGBORN CORP., 4400 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

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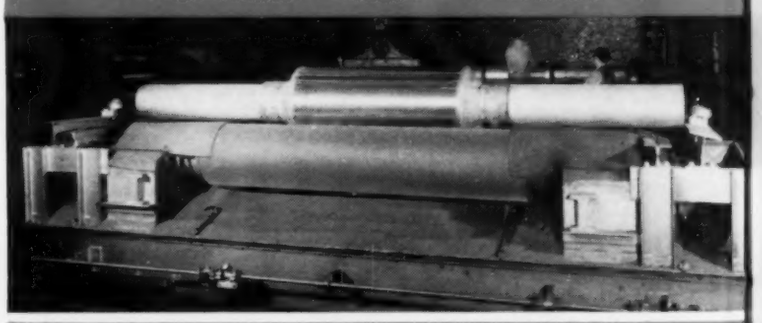
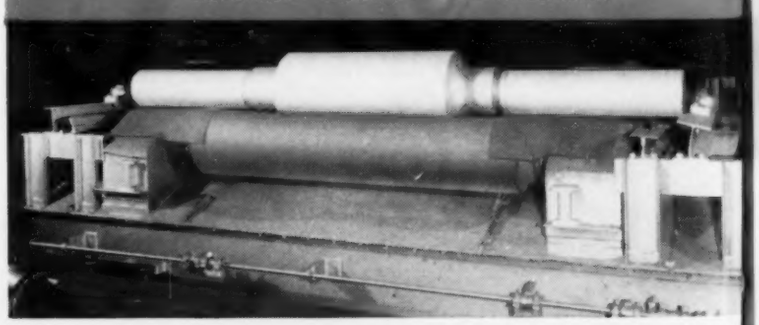


AFTER ROLL ETCHING



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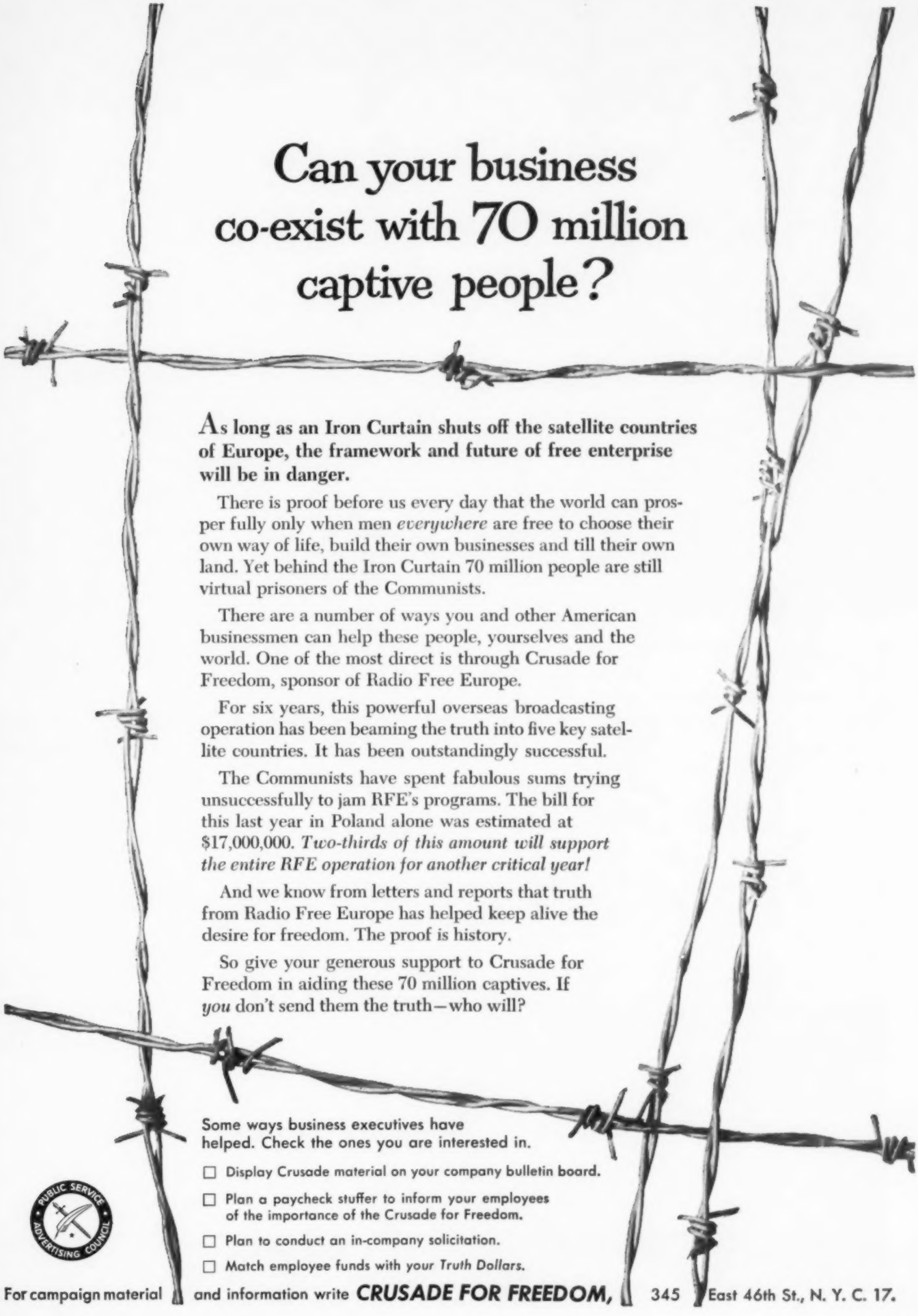

As long as an Iron Curtain shuts off the satellite countries of Europe, the framework and future of free enterprise will be in danger.

There is proof before us every day that the world can prosper fully only when men *everywhere* are free to choose their own way of life, build their own businesses and till their own land. Yet behind the Iron Curtain 70 million people are still virtual prisoners of the Communists.

There are a number of ways you and other American businessmen can help these people, yourselves and the world. One of the most direct is through Crusade for Freedom, sponsor of Radio Free Europe.

For six years, this powerful overseas broadcasting operation has been beaming the truth into five key satellite countries. It has been outstandingly successful.

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And we know from letters and reports that truth from Radio Free Europe has helped keep alive the desire for freedom. The proof is history.

So give your generous support to Crusade for Freedom in aiding these 70 million captives. If *you* don't send them the truth—who will?

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- ☐ Display Crusade material on your company bulletin board.
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- ☐ Match employee funds with *your Truth Dollars.*

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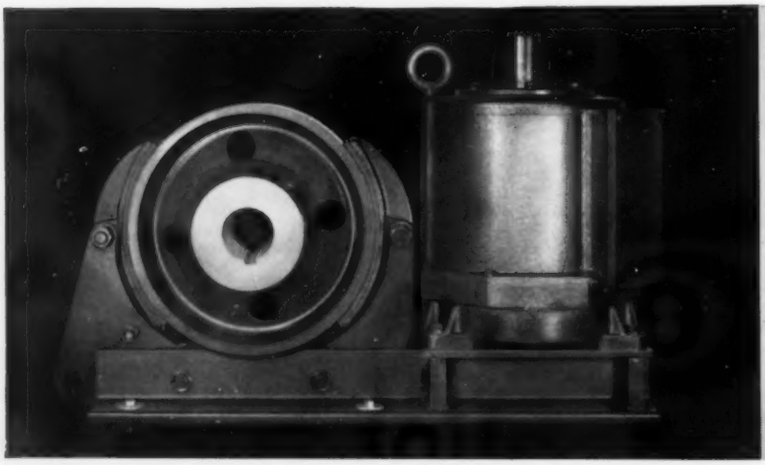

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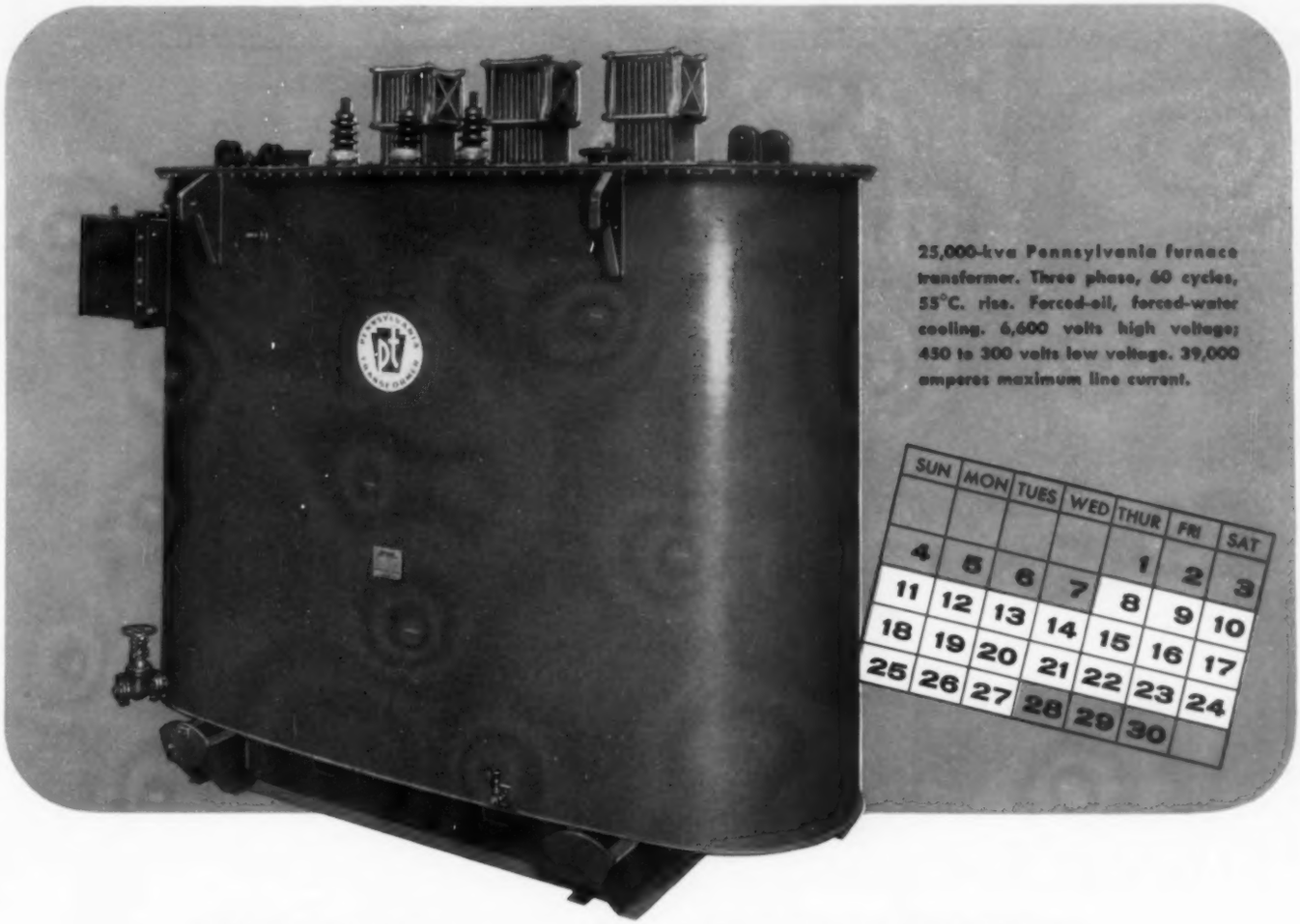

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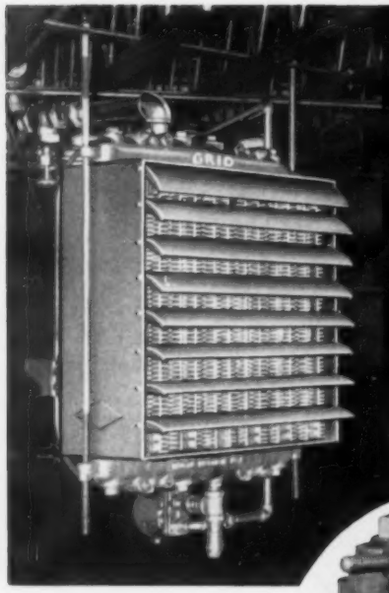
PENNSYLVANIA PENNSYLVANIA pt TRANSFORMER **FURNACE TRANSFORMERS**



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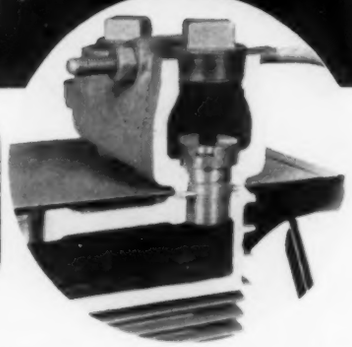

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Units available for capacities ranging up to 150,000 SCFM. Write for descriptive bulletin.

Performance summary of some P-A Washers now in use:

Installation	Years Operated	Volume SCFM	Pressure Drop Inches Water	Dust Loading Grains/SCF Inlet	Outlet
A	4	78,000	30	3-19.0	.01-.04
B	3½	78,000	30	2-3	.02-.08
C	3	85,000	30-40	2-3	.01-.03
D	3	45,000	30	2	.02-.03
E	½	75,000	50	—	.02
F*	½	26,000	12	5	.10
G*	½	26,000	12	5	.10
H	½	90,000	29	—	.04

Installation C is in Illinois. Installation H is in Texas.
All others are in Pennsylvania.

*Two units in parallel on one furnace. Lower efficiency due to lower available top pressure.

CHEMICO

P-A GAS SCRUBBERS

CHEMICAL CONSTRUCTION CORPORATION

A Subsidiary of Electric Bond and Share Company

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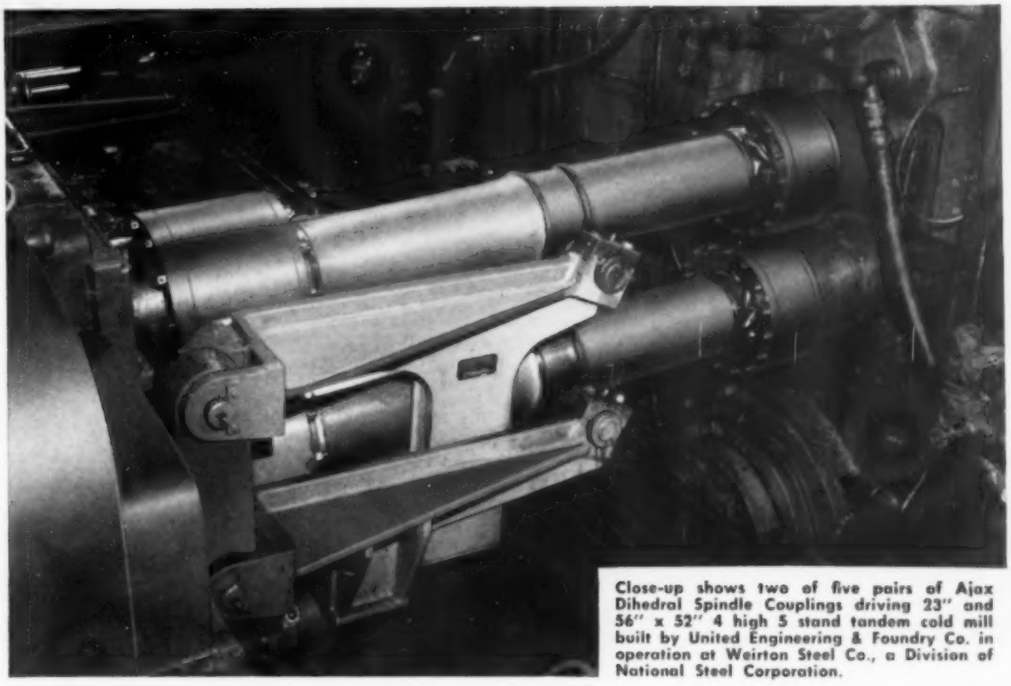
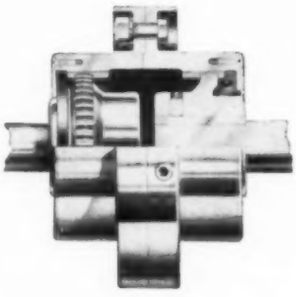
AJAX® DIHEDRAL COUPLINGS

SHORT CUT TO MAJOR PRODUCT IMPROVEMENT



Close-up shows two of five pairs of Ajax Dihedral Spindle Couplings driving 23" and 56" x 52" 4 high 5 stand tandem cold mill built by United Engineering & Foundry Co. in operation at Weirton Steel Co., a Division of National Steel Corporation.

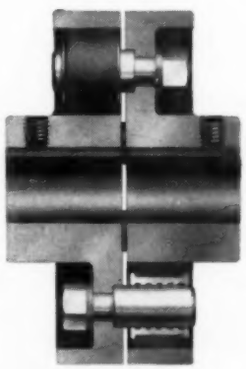


AJAX SERIES D-100

Dihedral Couplings handle shaft misalignment—offset and angular, up to 12°. Patented tooth design permits far less tooth clearance and provides more tooth area in contact under misalignment than with any other shaped tooth.

AJAX SERIES D-3000

Dihedral Couplings handle shaft misalignment up to 3°—yet cost no more than ordinary gear type couplings that have far less misalignment capacity. Johns-Manville "Clipper" Seals keep lubricant in and foreign matter out.



AJAX RUBBER-BRONZE BUSHED COUPLINGS

are built in a wide range of sizes and capacities with standard couplings made of forged steel or cast semi-steel. Flanges can be machined from aluminum, bronze and other metals, and can be chrome or cadmium plated for protection from adverse atmospheric conditions

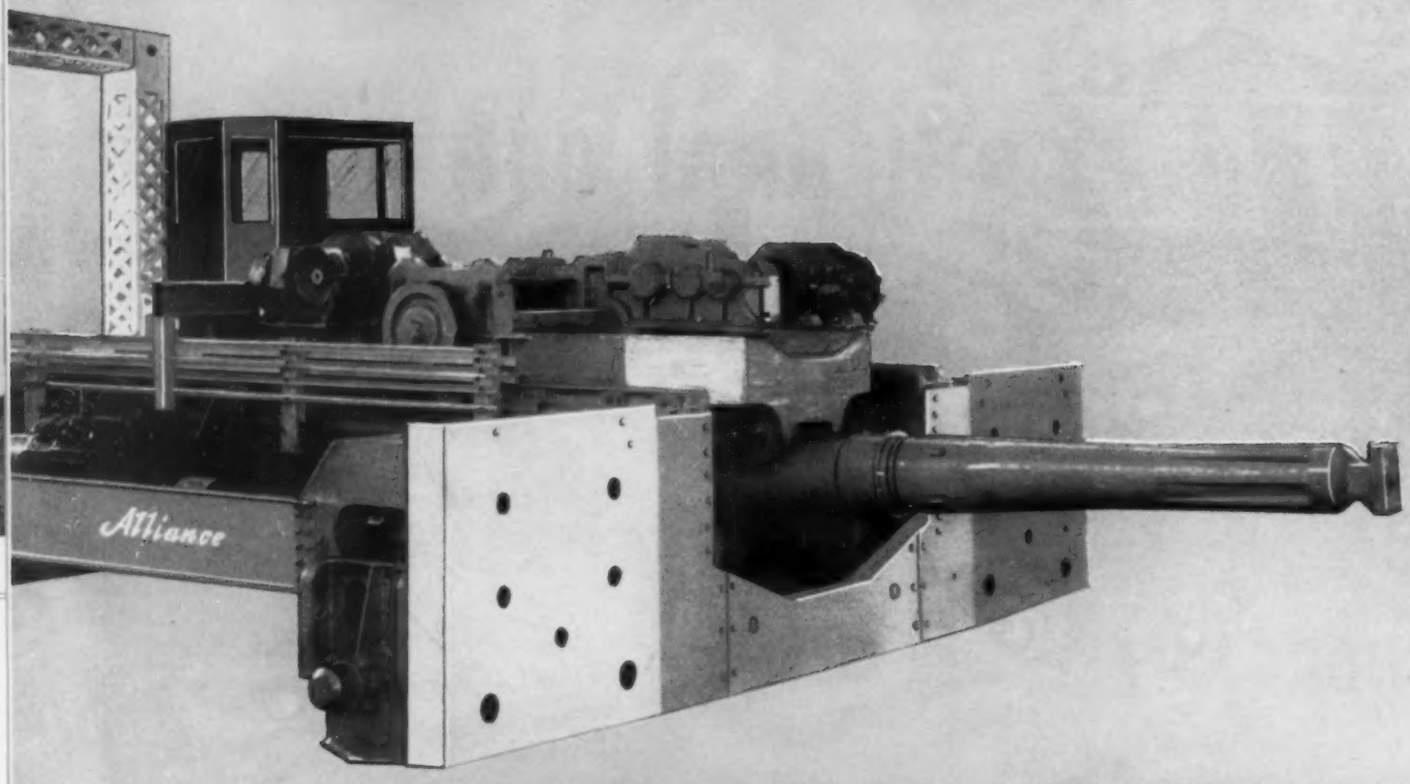
● Ajax Dihedral Couplings are major factors in new, improved product quality, machine performance and operating efficiency.

Ask any engineer—their selection of component parts rests upon a reliable source of technical information, and upon proving respectively the product and performance data. Ajax Dihedral Couplings handle any combination of angular and offset shaft misalignment up to 12°—greater capacities are available on special order. That explains why design and plant engineers specify and insist on Ajax Dihedral Couplings. Their proven performance in protecting millions of dollars worth of machinery in virtually every industry is why builders and users alike depend on Ajax Dihedral Couplings.

Write for your personal copy of the new Ajax Bulletin No. 62. It contains the misalignment capacities of every coupling type and size in the Ajax complete line of Flexible Couplings, or refer to SWEET'S Catalog, Product Design File.

Patented or Patents pending in U.S.A. and foreign countries.

AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, NEW YORK



This Charging Machine was built by The Alliance Machine Company, Alliance, Ohio . . . leaders in the heavy material handling equipment field for over 50 years. Contact Alliance for your requirements.

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SPECIAL MILL MACHINERY

STRUCTURAL FABRICATION

COKE PUSHERS

•

New 12-TON CHARGING MACHINE

• **The NEW Alliance 12-ton,** low-type open hearth Charging Machine has spring-loaded pitman so, if the charging box pushes up over scrap in the furnace, the trolley's front wheels remain on the rails. Trolley always has sufficient traction to retract peel and box from furnace.

• **Each bridge girder** of Alliance's NEW Charging Machines consists of two wide-flanged I-beams welded to form a box section. Between webs of this box section, diaphragms are welded at 3-ft. intervals. This, plus other welded reinforcements, keeps charging machine square and rigid.

• **Machinery deck plate,** extending full length of bridge between main girder and outrigger girder, laterally reinforces the main girder and helps keep charging machine square and stable under all operating conditions.

• **Stabilized, shock-absorbing wheels** operate at rear end of trolley. Two rear wheels engage upper rail; two adjacent wheels engage lower rail. Powerful springs hold wheels in contact with rails at all times. This spring suspension absorbs and disperses engaging and disengaging shock at end of the peel, reducing operator shock and fatigue to a minimum.

• **On eight-wheel bridges,** the four trucks located at corners of the bridge are equalized to compensate for any track irregularities.

• **New hydraulic lock rod** gives operator finger-tip control and eliminates laborious work incident to the hand-operated lock rod. All gears (including track wheel gears) are fully enclosed and run in oil.

WORLD'S LARGEST BUILDERS OF WORLD'S LARGEST CRANES

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GIVE US THE RUNWAY AND WE'LL LIFT THE WORLD

Equipment News...

ELECTRODE NIPPLE

▲ A new pitch impregnated nipple that increases electrode column joint efficiency has been developed by the Electrode Division, Great Lakes Carbon Corp.

Through a special process, the "Unitrode" nipple is paritally impregnated with a zone of pitch. This zone completely covers the outside of the nipple and permeates down to a predetermined depth. Inside the zone, the nipple remains porous.

As the electrode column is placed in operation, the pitch melts. At the same time, the air in the porous center of the nipple expands with the heat, forcing the liquid pitch throughout all the threads.

As the electrode column continues to heat, the pitch cokes out, strengthening the threaded joint and making a better bond throughout. This makes the joint stronger mechanically, which cuts down breakage. The tighter joint also keeps electrical resistance at a minimum, reducing differential expansion between the nipple and the electrode. This results in less joint splitting. The butt losses are smaller and less frequent.

REFRACTORY COATING

▲ Announced by the Refractories Div., H. K. Porter Co., Inc., is a new refractory coating said to reduce refractory costs and maintenance per ton of steel produced.

Known as "Metal Part," the coating is used for coating steel ingot stools, slag pots, and ingot buggy couplings. It is applied to hot metal surfaces (700 F max) without curling, and shields metal surfaces that come in contact with molten metal and slag.

On ingot stools, "Metal Part" reduces the percentage of stickers, (ordinarily 20 per cent to 30 per cent on uncoated stools). The coating increases stool life by retarding the progress of cavities. Slag pots coated with it will empty fast and clean. Buggy couplings coated with "Metal Part" do not develop troublesome and time consuming slag-welded connections. The principle ingredients of "Metal Part" are graphite, calcined aggregates and selected minerals. It has air-setting properties, a pyrometric cone equivalent of 32–33, and is applied to metal surfaces by gun, dipper, broom or brush.

BEARING ASSEMBLY

▲ Designed for steel furnace table shafts, a special Rollway Bearing Co. thrust bearing, with six-in. bore, has a load capacity of 76,500 lb at 100 rpm. Thrust load is carried at right angles to roll axis on 66 precision-ground cylindrical rollers, ¾-in. in diameter.

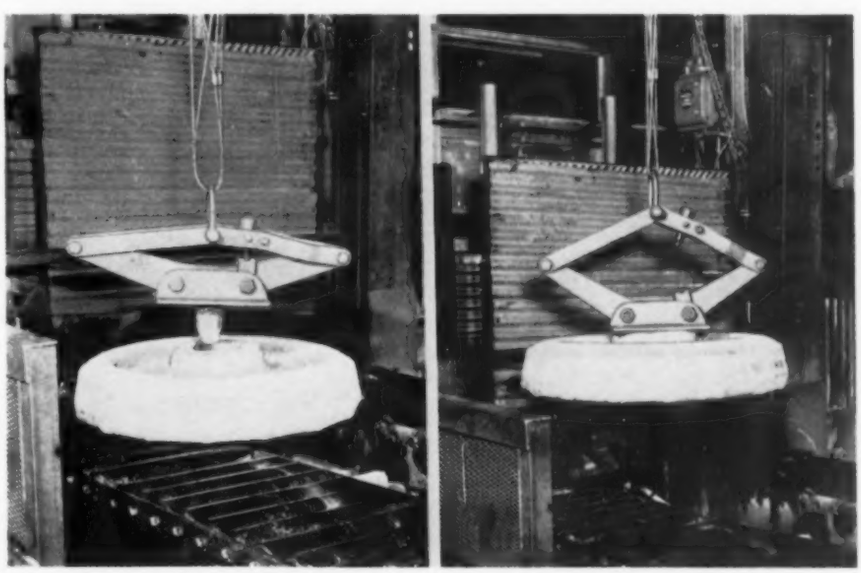
Rollers, of SAE-52100 steel, are through-hardened to 59–63 Rockwell C scale, and can withstand operating temperatures up to approximately 300 F. Rollers are accurately staggered to equalize wear distribution, and secured in machined bronze retainer by a heavy steel ring inserted over retainer's outer edge.

Extreme parallelism of thrust plates insures maximum linear contact. Outer diameter of stationary plate is ground for slip fit in housing; bore of revolving thrust plate is ground for slip fit on table shaft, with O.D. machined for clearance inside outer spacer sleeve. Face of the revolving plate is angled to relieve outer race of radial bearing. Spacer sleeves provided maintain proper operating float for unit.

Special Rollway Type ML radial bearing has 19 rollers, 1 in. diameter by 1 in. long, with a radial load capacity of 36,925 lb at 100 rpm.

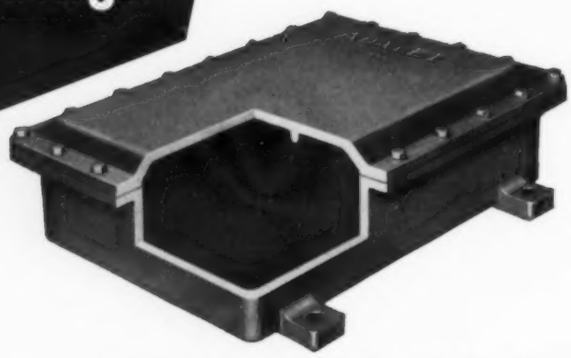
AUTOMATIC TONGS FACILITATE WHEEL HANDLING

Newly-forged wheel blanks, even though red hot, are lifted safely and quickly with these specially designed automatic tongs made by Heppenstall Co. The tongs are made with jaws that press against the bore of a blank, rather than by grasping the blank around its circumference. The jaws are locked at their minimum width of 3½ in. when lowered for lifiting, but can be opened to 8½ in. wide. The lifting edge of each jaw is serrated to give it more grip. The tongs have a capacity of 2000 lb. At left, the tongs are being lowered over a wheel blank, with the jaws locked at the minimum width so that they can be inserted in the bore. When the tongs are raised, the locking mechanism is automatically released, causing the jaws to push against the bore from two directions. Because of the linkage principle of the tongs, the weight of the load causes it to be held firmly. At right, the blank is being lifted. The tongs are designed so that the load cannot be released until it again rests on a firm surface. Lowering the tongs a few additional inches is then sufficient to lock the jaws at their minimum width, ready for picking up another load.



Explosion-proof Housings

cast aluminum



Non-sparking cast aluminum, strong and rustless. Available in a wide range of standard and special sizes.

Lightweight, easily mounts onto equipment. Drilled and tapped to specifications. Made to Underwriters and Military Specifications.

Send for Bulletin F

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BEST BY DESIGN

Not by Chance

Constant attention to the wants and needs of users, has been worked into the finished recorder by trained designers, who devote their entire effort to producing the best in direct-writing recorders. *E-A Recorders are designed to be the best.* Performance has proved their superiority.

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PRODUCT REPRESENTATIVES IN MOST PRINCIPAL CITIES

The ESTERLINE-ANGUS Company, Inc.
Pioneers in the Manufacture of Graphic Instruments
Dept. F5, P. O. Box 596, INDIANAPOLIS 6, INDIANA

Separable outer race has single flange; roller assembly is self-contained in double-flanged inner race. With $\frac{1}{32}$-in. minimum axial float on table shaft, the radial bearing has a thrust-load capacity of 17,300 at 100 rpm.

CHARGING UNITS

▲ Salem-Brosius, Inc., has announced a new line of all-hydraulic furnace charging machines.

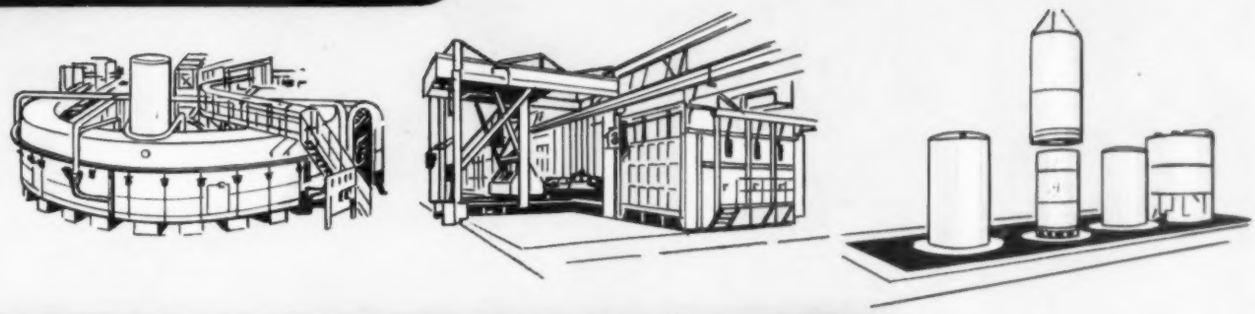
Available in eight sizes ranging in capacity from 2000 to 20,000 lb, the machines are designed to use diesel, gasoline or propane engines or plant electricity as the primary power source. They are furnished with boxes for charging scrap, limestone and other loose materials into melting furnaces or with various designs of tongs to handle ingots, billets, blooms, slabs and other solid forms.

The rugged, heavy-duty machines are in operation in plants requiring continuous furnace charging service. As tricycle-type machines equipped with solid rubber tires, they are extremely maneuverable and will turn on their own wheel-base.

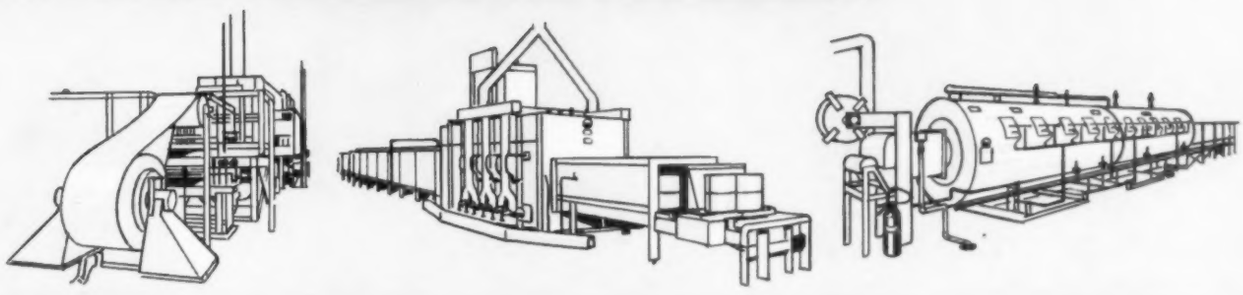
The basic power source drives hydraulic pumps which in turn provide power for all operations. These include raising, lowering, tilting and rotating the box or tongs work head and moving the machine over the charging floor. One man, at the hydraulic control pulpit mounted on

This 2000 lb charging machine uses plant electricity as its primary power source.

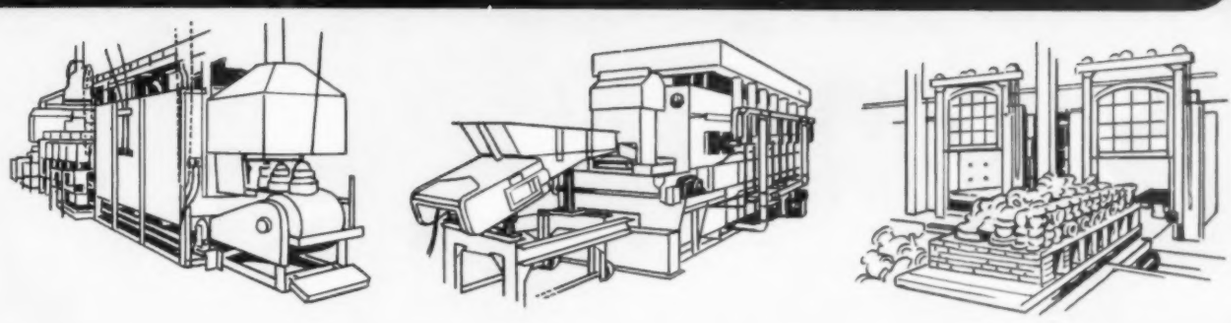
EF BUILDS



ALL TYPES AND SIZES



GAS FIRED, OIL FIRED and ELECTRIC



including the one that's best for you

It costs less to let experienced heat treating engineers handle all phases of your heat processing furnace projects. Then you can be sure the design and type of furnace, the method of heating, the special atmosphere, the material handling and other equipment are all best suited for your plant, product and process. All phases can be synchronized and coordinated to your production schedules, assuring the utmost economy and efficiency, and profitable, trouble-free operation.

With more than 40 years of continuous research and experience, and thousands of successful gas fired, oil fired and electric installations, EF engineers are qualified to design and build the sizes and types you need for any heat processing requirement.

On your next furnace project, no matter how large or unusual, let EF engineers work with you. Our wide experience and complete research, engineering, manufacturing and erection facilities are "at your service."

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GAS FIRED, OIL FIRED AND ELECTRIC FURNACES
FOR ANY PROCESS, PRODUCT OR PRODUCTION

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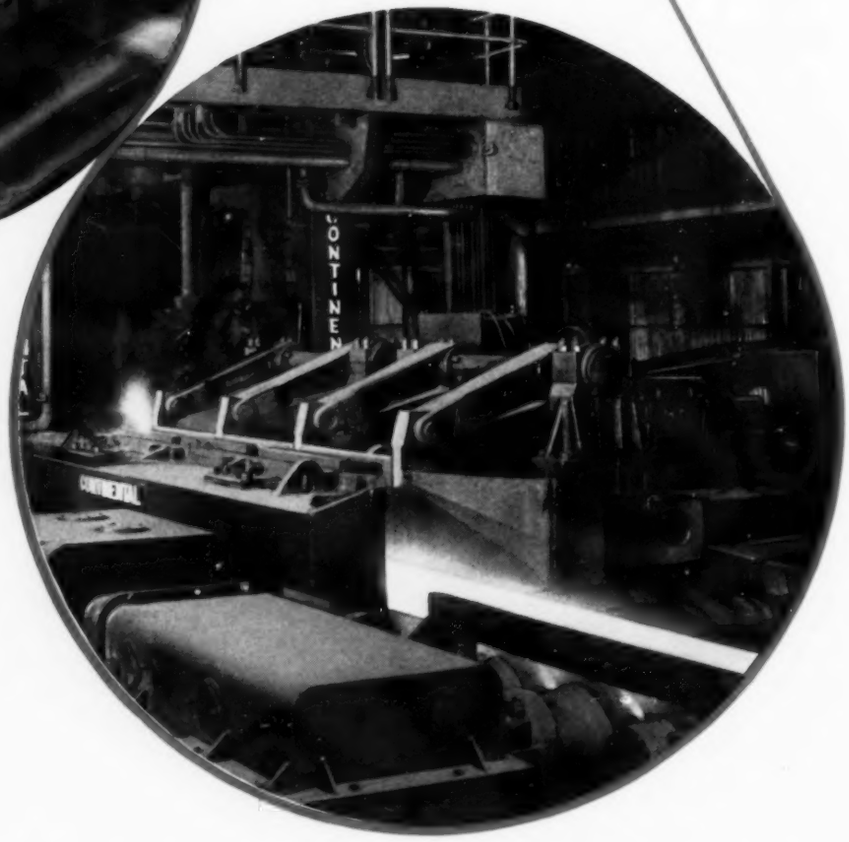
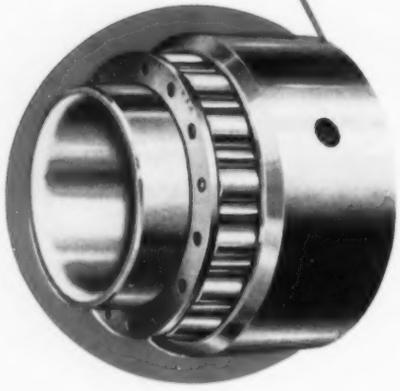
Hyatt's new production methods here . . .

mean smoother production for you here!





THINGS RUN SMOOTHER ON . . .

Today we're investing a lot of time, engineering talent and dollars in ultra-modern, electronically-controlled production and testing equipment. It assures a new standard of quality—*electronic precision*—in every new HYATT Hy-Roll Bearing. It means smoother running, longer service and significant savings for you.

By standardizing on new HYATT Hy-Rolls on your ingot and charging cars—main, approach and runout tables—feed rollers and lineshafting—you can be sure of *even finer* bearing performance than HYATTS have been famed for in the past! Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

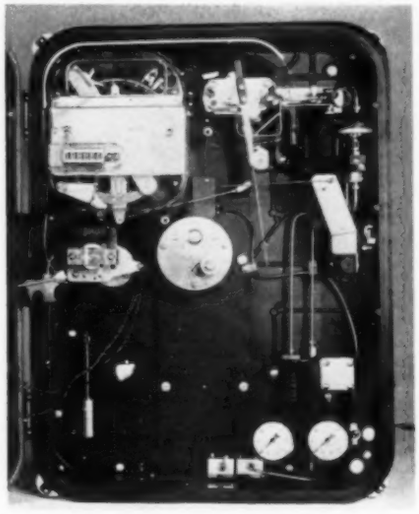
HYATT HY-ROLL BEARINGS FOR STEEL INDUSTRY

the machine, is in complete control of all functions.

The furnace charging machine eliminates the use of cranes, conveyor tables, counterweights, porter bars and other auxiliary equipment required for furnace charging, and leaves valuable floor space clear of tracks, conveyor tables and other permanently mounted equipment.

RING BALANCE METER

▲ A ring balance meter, used for recording, indicating and controlling process variables involving differential heads, flow, absolute pressures up to 20 psia, liquid specific gravity, etc., has been developed by Hagan Chemicals & Controls, Inc. The meter's actuating element is a hollow ring fitted with a baffle in the top and partly filled with a heavy fluid. Differential pressures, admitted through flexible S tubes to the ring on opposite sides of the baffle, give the ring a tendency to rotate around its axis and actuate the pen mechanism. The S tubes eliminate static pressure effect, and the high ratio of ring torque to friction in the



knife-edge bearings results in a sensitivity of one in 1000. Instrument accuracy is plus or minus 0.5 per cent of full-scale range down to 10 per cent of scale. Any individual meter can be used for measuring the differential of any type fluid within range of the ring assemby, and without any major changes.

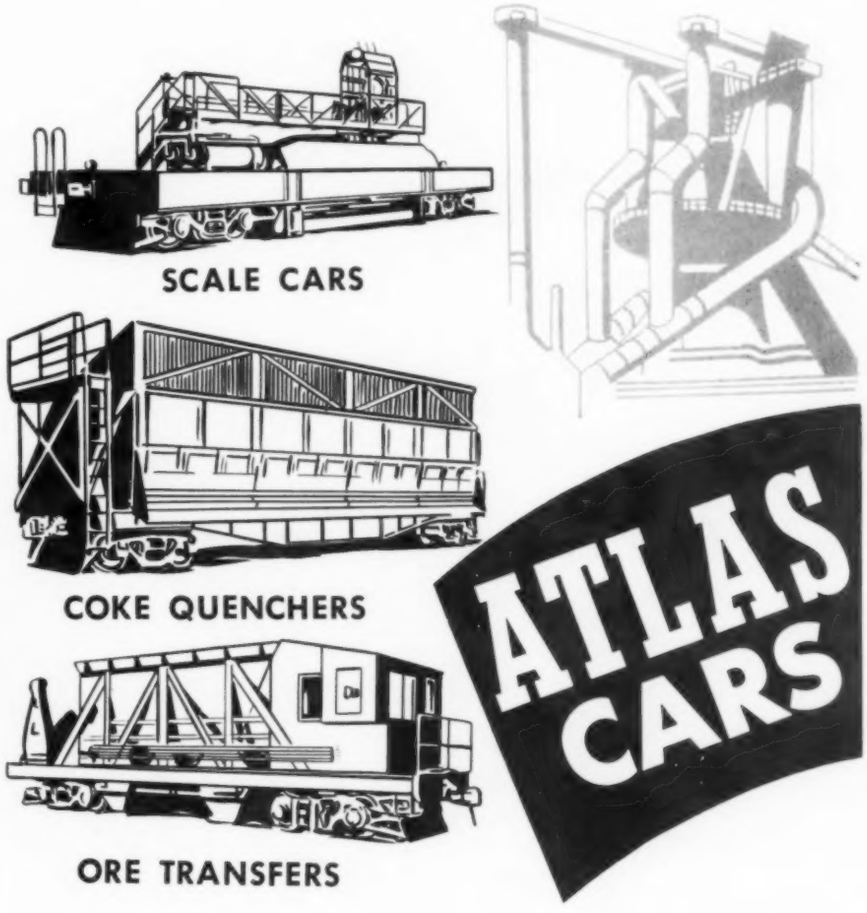
Pneumatic and electrical transmitters may be added to all types of ring balance meters for remote service in recording, indicating or integrating, or for actuating elements of automatic control systems. Receiver type meters are also available for accepting these pneumatic or electronic signals from remote sources.

Many combinations of instrumentation are possible with these meters. Dual type instruments contain two separate rings in a single case for simultaneous measurements. Computing linkage assemblies are available for addition and subtraction, or for calculation of ratio for recording or control purposes.

This dual arrangement can be used to register boiler steam flow-air flow ratio, compute flow in steam, gas, air and liquid distribution systems, measuring net solids in a liquid system, controlling air-gas mixtures, measuring heat transfer in air conditioning and refrigeration systems, etc.

Movement of the incorporated integrator is proportional to pen position and continues down to 2 per cent of full scale. Totals are shown on a six-figure cyclometer, which may be read without opening the case.

Easy accessibility is built into each instrument through the use of a



These cars are built to give the dependable service required for continuous furnace operation. All approved modern safety devices are incorporated for extra factors of safety.

Each car is engineered to meet the operating conditions of the plant where it will be used.

CONSULT ATLAS FOR YOUR STEEL PLANT CARS

THE ATLAS CAR & MFG. CO.

ENGINEERS MANUFACTURERS

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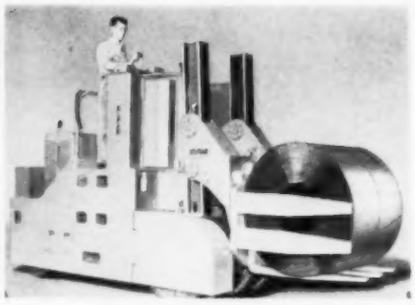
sectionalized case. A swinging front and a four-piece back permit complete checking and recalibration without disconnecting the meter or removing it from its mounting. Test weights are used for checking instead of unwieldy manometers.

COIL TRUCK

▲ A 20,000-lb capacity coil handling truck equipped with a unique rotating head, has been announced by the Elwell-Parker Electric Co.

In operation, the truck, picks up coils which are stored in a horizontal



position, upends them during travel, and deposits them in a vertical position so they may be conveyed through the annealing furnace. After annealing, the truck may again be used to change their position before replacing them in storage.

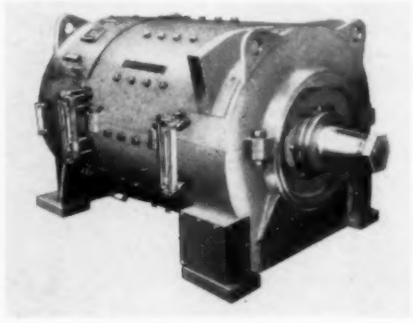
The new truck thus eliminates the need for a stationary upender, and because of its mobility, may be used for other handling jobs of loads up to ten tons in weight.

MILL MOTOR

▲ A new, more powerful auxiliary mill motor, the MD-624, has been announced by General Electric Co.'s Direct Current Motor and Generator Department. Built to AISE standards, it is rated 500-hp (cont. 75 C) 340-rpm, 230-volt, shunt wound. The new motor delivers 41 per cent more torque than the MD-622, largest AISE standard motor previously available in the line.

An extension of the General Electric MD-600 mill motor line, the MD-624 retains the design features characteristic of the line.

Armature and field coils are fully Class H insulated. Frame is heavy



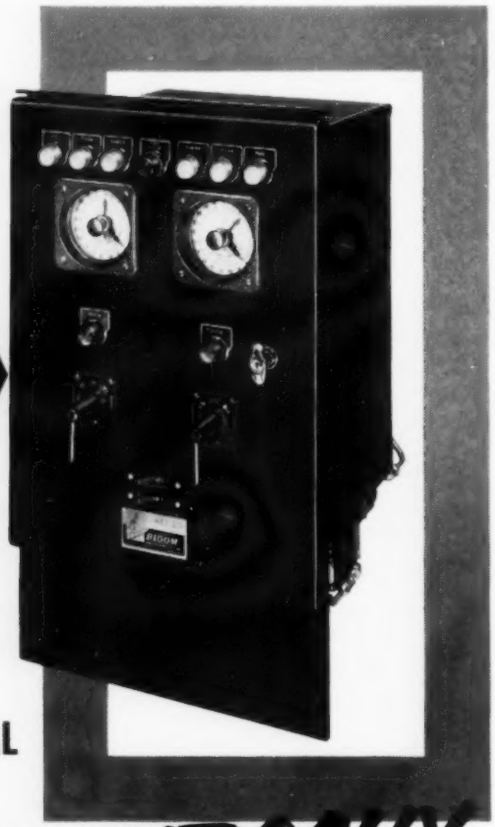
rolled steel, split for maximum accessibility. Frame heads have integrally cast feet for easy repair or storage of armature and frame head assembly. Constant force brush springs maintain even pressure throughout brush life. Pole-face compensating windings provide wider speed range.

First application of the new motor will be for slab shear drives. Other applications requiring the greater horsepower provided by the MD-624 include edger drives, mine hoists, car dumpers, mandrel drives, ore bridges, levelers, skip hoists, and flanging machines.

PNEUMATIC MARKER

▲ Pannier Corp.'s single impact pneumatic marker is a new portable air marker for hot or cold metal marking. It is a light weight tool for marking clean, clear impressions on parts that are not easily moved to within range of a regular marking machine.

The BLOOM Time-Cycle Reversal Unit assures FULL, FAST AND EFFICIENT REVERSAL OF REGENERATIVE FURNACES AUTOMATICALLY



This complete, compact, factory-tested unit provides a combination electric-pneumatic system for Open Hearth Furnace and Soaking Pit reversal. It elimnates reversal puffing and shortens reversal period. (10 to 15 seconds easily accomplished).

Shorter reversal cycle improves furnace life.

These units have been in continuous service for nine years. Trouble-free maintenance.

BLOOM ENGINEERING CO., INC.
837 W. North Avenue Pittsburgh 33, Pa.

WRITE or phone for complete information on the Bloom Time-Cycle Reversal Unit.

The Principle That Builds Better Gears, Joints and Axles

When DBG built their first automotive gear back in 1912, a principle was born: "Build an outstanding product at a competitive cost . . . but never sacrifice quality for price."

Word spread. DBG grew. People who asked us to design or build one product asked us to design and build other types. Result: now, you'll find DBG products in fields as diverse as aviation, automotive, instrument, road building and heavy construction equipment. DBG quality is found in power take-off universal joints and heavy duty drivelines . . . instrument gears and gears for giant off-the-road equipment. The result is a wide range of drivelines, bevels, gears and axles, and *only* a *few* are shown above!

Why not capitalize on this experience? Write or phone *today*.

Drivelines
Bevels
Gears

57A

DETROIT BEVEL GEAR COMPANY

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BETTER LUBRICATION

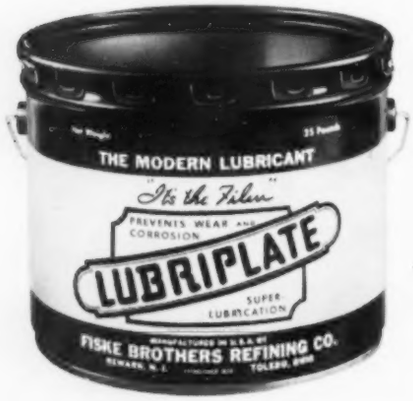
FOR BALL AND ROLLER
BEARINGS

BALL BEARING LUBRIPLATE . . . a most effective grease type lubricant that also protects ball and roller bearings against rust and corrosion. Highly recommended for speeds up to 5,000 RPM and temperatures up to 300° F.

LUBRIPLATE No. 205 . . . an unusually light consistency, grease type lubricant made for use in anti-friction bearings operating at speeds in excess of 5,000 RPM.

LUBRIPLATE Nos. 1, 2, 4 and 8 are fluid type lubricants of various viscosities that have given outstanding results in anti-friction oil type bearings. Nos. 1 and 2 are recommended for high speed applications; nos. 4 and 8 are recommended for slow speed, heavy load applications.

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Write for free "LUBRIPLATE DATA BOOK". . . a valuable treatise on lubrication. LUBRIPLATE DIVISION, Fiske Brothers Refining Company, Newark 5, N. J. or Toledo 5, Ohio.



The usually slow and often dangerous hand marking of large metal parts is eliminated by the portability and operating convenience of this unit. Heavy castings, forgings, etc., receive an accurate impression free of "chatter" marks, every time. It's light weight—only 12 lb including type head and type—and is easily carried about on the end of an air hose. The portable hammer has its own surge chamber so that distance from main air supply does not affect its impression uniformity. Air pressure as low as 50 lb will operate this hammer.

Interchangeable type holders will accommodate six $\frac{3}{16}$-in. characters, four $\frac{1}{4}$-in. characters, or individual characters up to $\frac{1}{2}$-in. The fast type-changing features allow you to change type, or change entire holder, quickly and safely.

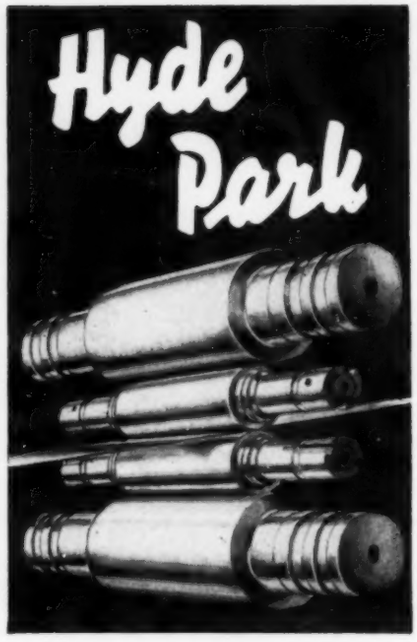
SELF-REDUCING ALLOY

▲ A new self-reducing vanadium alloy is now being produced commercially by Electro Metallurgical Co., Division of Union Carbide Corp. Extensive laboratory and field tests have indicated that the alloy is an economical, highly soluble source of vanadium for electric furnace steels.

The new alloy contains a reducing agent which reduces vanadium oxide and yields vanadium quickly and uniformly to the steel bath. It has been used to add as much as 0.80 per cent vanadium to commercial heats of tool steel, with vanadium recoveries of 98 to 100 per cent being reported. High recoveries can also be expected when self-reducing vanadium is added to constructional alloy steels and high-temperature alloys made in the electric furnace.

In the production of tool steel, self-reducing vanadium is generally added to a well-reduced carbide slag during the finishing stages of a heat. In one series of tests, self-reducing vanadium was added to several heats of molybdenum-base, high-speed tool steel made in a 5-ton basic electric furnace. Forty lb of vanadium per 13,000 lb heat (0.31 per cent vanadium) were added toward the end of the reduction period. The recovery of vanadium exceeded 98 per cent. There was no appreciable pickup of the reducing agent.

The ingredients of self-reducing



Red Circle Rolls for all Purposes

The Red Circle on the Roll is the Hyde Park mark of Quality. Hyde Park makes rolls for every type mill.

Chilled Rolls
Alloy Iron Rolls
Moly Rolls
Nickel Chilled Rolls
Grain Rolls
Cold Rolls
Sand Rolls

for
Finer Finish, Longer Life
and Greater Tonnage
specify Red Circle

Hyde Park

FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS • ROLLING MILL MACHINERY
GREY IRON CASTINGS

Bearings, Inc. customers . . . are the best "price buyers" in business!

Take this steel mill as a good example. The Superintendent of Mechanical Maintenance and the Master Mechanic shown above talking to our sales representative, buy many bearings at competitive prices from Bearings, Inc. every year. By using our services to their fullest extent . . . By accepting the knowledge of Bearings, Inc. engineers, they get a "value added" that makes their bearing purchases far less expensive than can be supplied by most other distributors.

Here are some of the services Bearings, Inc. is continually performing for this mill:

- An original survey, made before a new rod mill went into operation, catalogued each of the 8,000 bearings in the mill as well as oil seals and bronze bushings. A weekly recap keeps the inventory up to date.
- Reducing duplication and elimination of bearings no longer needed through periodic checks.
- Suggesting methods which have improved quality of product, lessened maintenance costs and lengthened machinery life.
- Conducting educational meetings among plant workers, showing them how they may cut maintenance costs.
- Re-wrapping stock to keep out dirt.
- Availability for consultation about plant problems. A telephone call will bring the Bearings, Inc. man in a hurry if the problem cannot wait until his regular call.
- Helping set up a preventive maintenance system enabling this steel mill to find potential breakdowns before they happen.
- Relocating stockrooms for greater efficiency.
- Standardizing bearings wherever possible.

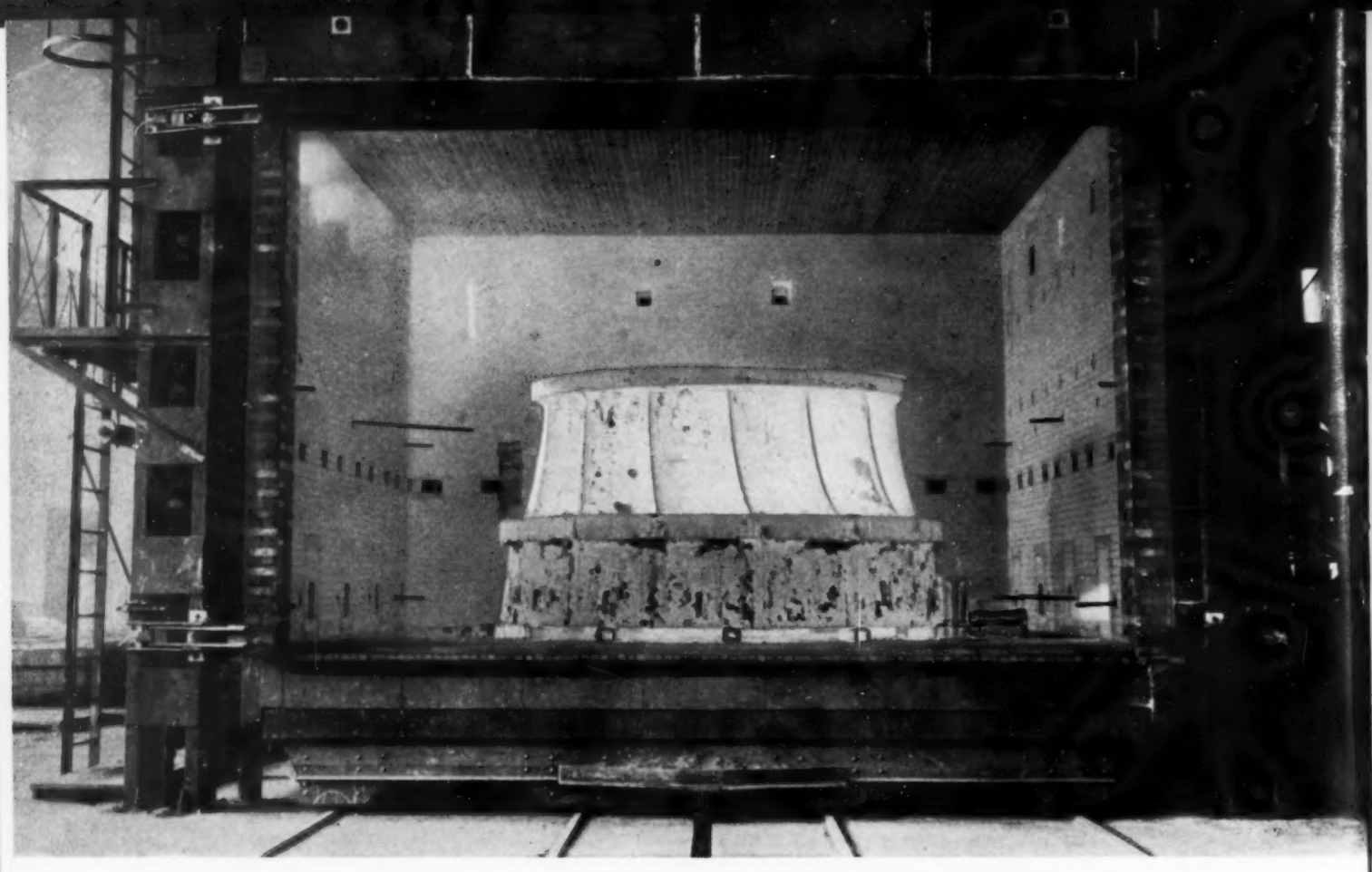
Most of our customers know and use these services.

A call to our nearest branch will make them available to you!

Providing bearing service in the territories adjacent to our branches, listed below.

BEARINGS, INC.

OHIO: Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton • Lima • Mansfield • Toledo • Youngstown • Zanesville
INDIANA: Ft. Wayne • Indianapolis • Muncie • Terre Haute
PENNSYLVANIA: Erie • Johnstown • Philadelphia • Pittsburgh • York
WEST VIRGINIA: Charleston • Huntington • Wheeling
NEW JERSEY: Camden • **MARYLAND:** Baltimore
DELAWARE: Wilmington •
Subsidiaries: Balanrol Corp. • Buffalo, N.Y.•
Kentucky Ball and Roller Bearing Co. • Louisville, Ky.



For best performance and maximum economy

7 different specialized refractories used in annealing furnace lining

Engineering a furnace lining with *specialized* refractories can save dollars on construction, fuel and maintenance as well as extend productive working time. To achieve these results, seven different B&W refractories were used in the lining of this 25′ x 23′ x 14′ annealing furnace.

Fuel savings and close temperature control were made possible by using three types of *lightweight* B&W Insulating Firebrick. Walls are composed of *B&W K-23 IFB* backed up with *B&W K-16*. Because of the proximity of the burners, the roof was constructed of *B&W K-26 IFB*, a higher temperature brick to guard against the effect of possible localized overheating.

The weight saving construction means about 100 lb less refractory material to heat up per sq ft than with ordinary firebrick, or about 28 tons less in the roof of the furnace. Furthermore, supporting steel is less massive, far less costly. Commercial size steel can be used for roof suspension instead of special steels.

To eliminate the need for expensive special shapes, the burner tunnels are formed of *B&W's 3000 F refractory castable, Kaocast*. Lintels over the burners and jambs are constructed of rugged *B&W Junior Firebrick*.

To take advantage of fast, easily installed castable construction, *B&W Kaocrete-D* was used in the nose arch (separately pictured). This sturdy castable with a 2500 F use limit was selected to provide strong resistance to abrasion caused by door operation. In addition, the need for costly fired shapes and their supporting castings was eliminated, as was a great deal of expensive engineering detailing.

Nose arch, cast of B&W Kaocrete D, immediately after removing forms.

The car top is insulated with *B&W Kaolite-20*, a 2000 F insulating refractory concrete.

For further information, write for B&W bulletin R-2-H on insulating firebrick and B&W bulletin R-35 on castables.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

R-574

vanadium are thoroughly dried during production and packed in moisture-proof cans to insure that the alloy is completely moisture-free when added to the steel bath. Each can contains exactly five lb of vanadium, eliminating weighing of vanadium additions. The cans can be palletized for easy handling, storage, and inventory control.

Self-reducing vanadium is the second "self-reducing" alloy that Electromet has developed. Commercial production of the other alloy—self-reducing tungsten was started about two months ago.

FLOW METERS

▲ A complete new line of dual-range flow meters is now being marketed by Air Reduction Sales Co. Known as the 1600 Series, they are designed for inert-gas welding, flushing molten metals, laboratory service, and many other industrial applications where accurate control and constant visual check of flow rate are required.

Flow ranges of the new flow meters are sufficiently wide to meet gas demands formerly requiring more than one metering device. Rapid in-service switching from either flow range to the other is done by means of a piston-type selector valve. Flow rate within either range is controlled by a sensitive needle valve. Accuracy is maintained under all service conditions and is not affected by back pressures.

The series includes seven direct-reading flow meters, each for a specific gas, and one general-purpose flow meter, provided with calibration curves, which will meter any of five gases. A combination of two or more flow meters can be used to proportion a mixture of gases.

The flow meters can be attached to cylinder or pipeline regulators, directly to pipelines, or they can be bench or wall mounted by means of the special mounting clamp supplied.

SYNCHRONOUS STARTERS

▲ Synchronous starters (2200–4800 Volts) which provide a simple, safe method for starting and bringing synchronous motors into synchronism are available from Electric Controller & Manufacturing Division, Square D Co. A push of the "Start" button gives complete protection during starting and running—plus fully automatic synchronization. Throughout the entire sequence, motor windings are completely protected and synchronization occurs at the most favorable time.

Should the motor pull out of step because of voltage dip or overload, the field is automatically removed. Re-synchronization occurs when the motor re-accelerates the load. Short circuit protection is provided by current-limiting power fuses working in conjunction with high-interrupting-capacity ZHA air-break contactor.

BUTTONS—SWITCHES

▲A new line of Bulletin 800 standard duty push buttons and selector switches with a unique, molded wrap-around cover which contains and protects the contact mechanism, has been announced by the Allen-Bradley Co.

The contact mechanism of the push buttons is contained and protected in the wrap-around cover. Removing the cover exposes the wiring terminals in the base. Actual tests have shown that the new push buttons can be wired in half the time usually required. A molded Bakelite shield completely covers and protects the contact mechanism when the cover is removed. Careless wiring cannot interfere with contact operation when the unit is assembled.

The base terminals are connected to the push button assembly in the cover through heavy, silver plated contacts. Matching ribs in the molded cover and notches in the terminal base make it impossible to mount the cover in any other than the right manner—contact connections cannot be made incorrectly. Concentric knockouts are provided in both the top and bottom of the heavy metal base for convenient wiring. Furthermore, the push buttons themselves can be easily rotated 90 deg for mounting the station in a horizontal position.

The new standard duty push button stations are available in NEMA 1 enclosures with one, two, and three buttons, or two buttons and a pilot light.

(*Please turn to page 240*)

ALLIS-CHALMERS

Products for steel: motors, m-g sets, rectifiers, control, pumps, *Texrope* drive equipment, crushers, grinding mills, screens, transformers, unit substations, switchgear, circuit breakers, turbine-generators, voltage regulators, blowers, compressors, condensers, and water conditioning equipment.

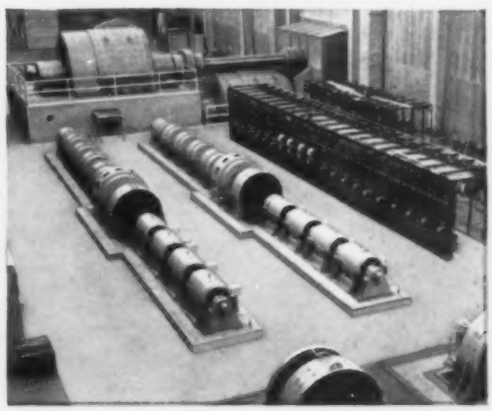
ALLIS-

in Step with STEEL

The blooming mill

Maximum electrical efficiency is assured in blooming mill operations where Allis-Chalmers equipment is used. From switchgear to drive motors, Allis-Chalmers offers a tailored system — engineered by mill experts and designed to keep high quality blooms rolling fast and accurately.

From mine to final processing—Allis-Chalmers equipment is in step with the increasing tempo of expanding steel production. Contact the nearest A-C office in your district, or write Allis-Chalmers, Milwaukee 1, Wisconsin.



Blooming mill motor room view shows components of the Allis-Chalmers electrical package. Switchgear, control, constant and variable voltage motor-generator sets, *Regulex* motor-generator sets, liquid rheostat, and twin drive motors are designed to work together for peak mill output.

Regulex and *Texrope* are Allis-Chalmers trademarks.

CHALMERS

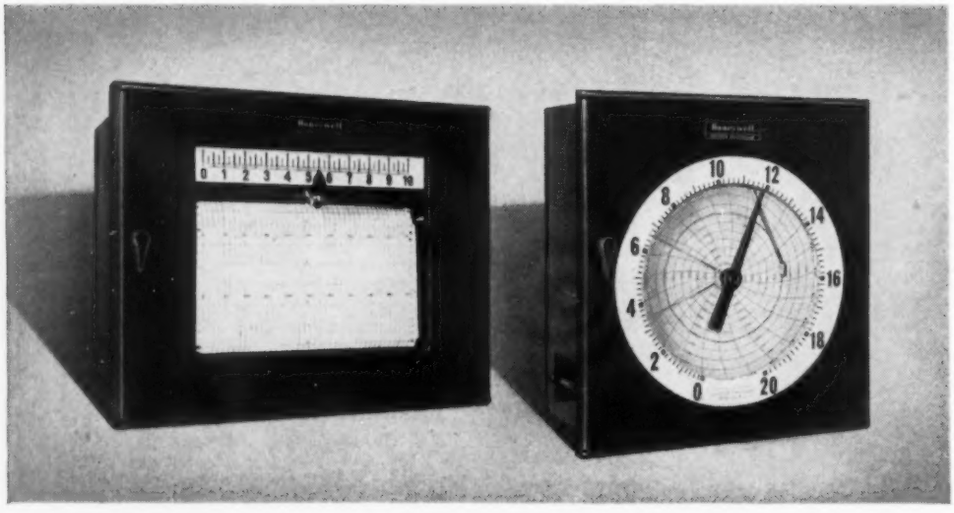
A-C ALLIS-CHALMERS

A-5411

• *for accuracy, versatility, price*

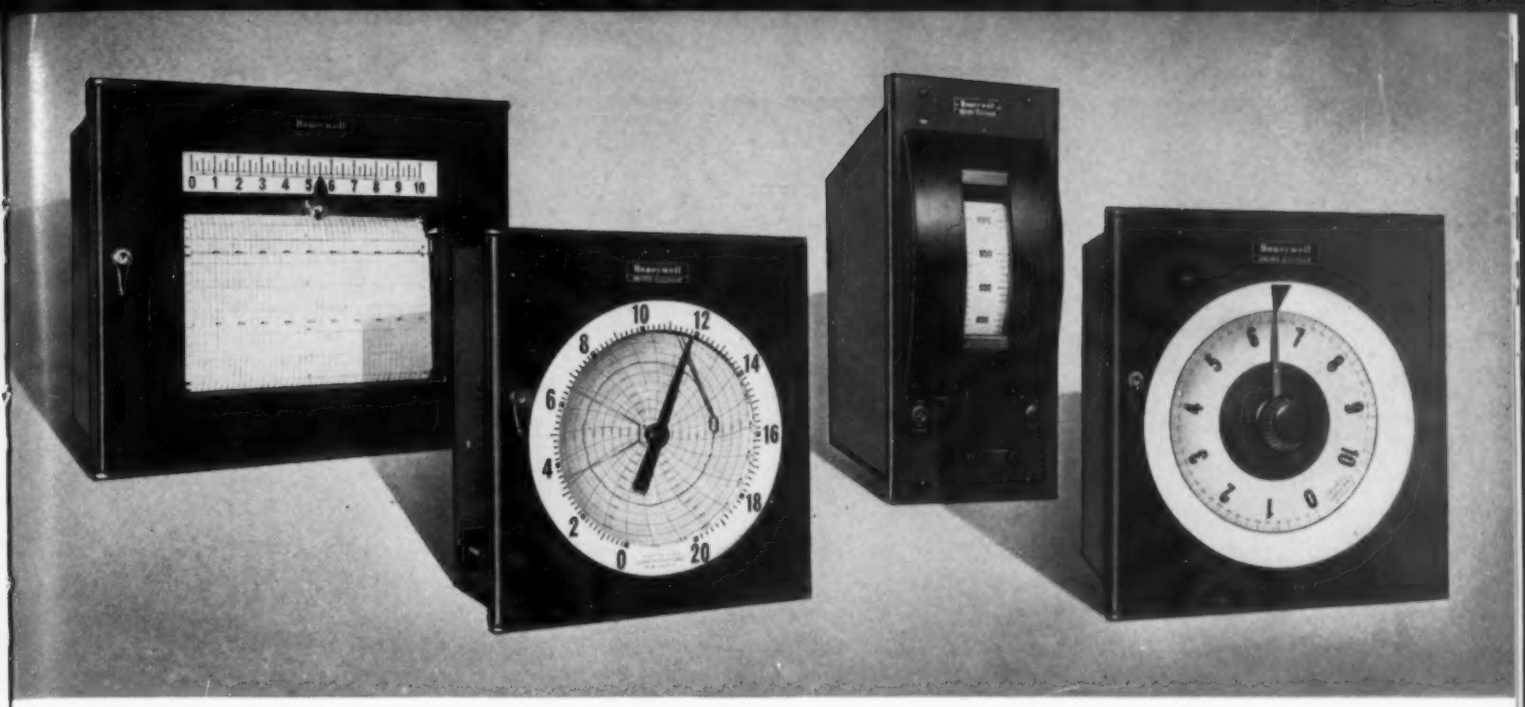
The Precision Class 15 Line of *ElectroniK* instruments has calibrated accuracy within ±.25% of scale span. Models include strip and circular chart recorders, Precision Indicators, circular scale indicating controllers, Vertical Scale Precision Indicator. Electric and pneumatic control from simplest to most complex types. Multi-point monitoring or recording of 2 to 400 separate inputs.

...Let your application decide



The Special Class 14 Line of *ElectroniK* instruments is calibrated to an accuracy of ±.5% of scale span . . . priced lower than the Precision line. Includes strip chart and circular chart recorders and recording controllers, also circular scale indicating controllers. Electric control of the contact, time-proportioning or position-proportioning type is available.

Millivoltmeter Instruments give dependable and accurate service, at low cost. High-resistance galvanometer circuit minimizes effects of varying length of extension wires. Plug-in unit design speeds servicing. *Pyr-O-Vane* controllers, in either horizontal or vertical case, give snap-action electronic vane control or pulse-type time-proportioning control.



which Honeywell instrument

fits your needs

Got a temperature measurement or control job to handle? There's no need to "shop around." For from *one* source—Honeywell—you can be sure of getting exactly the right instrument to fit your needs.

This is the time-saving—and money-saving—way to choose instruments. You can choose from the most complete, most diversified line of pyrometric instruments on the market. Your selection can hit the application right on the button—giving you the performance you need at the price that fits your budget.

For the peak in precision and versatility, there's the "Precision" *ElectroniK* line. This is the pioneer "continuous balance" electronic instrument that thousands of plants and laboratories have used for many years. It's available in eleven basic models, and can provide automatic control action from the simplest to the most advanced types.

For less exacting applications, a new series of instruments—the "Special" *ElectroniK* line—is now available. They provide many of the forms of automatic control you can get with the "Precision" line. And they cost less . . . bringing *ElectroniK* performance within the reach of even wider areas of application.

For simplified indicating control, Honeywell offers a line of economical millivoltmeter instruments . . . *Pyr-O-Vane* controllers, with a variety of electric control forms . . . and *Protect-O-Vane* controllers for excess temperature safety cut-off.

Your local Honeywell engineer will be glad to help you determine which type of instrument best fits the needs of your own application.

Call him today . . . he's as near as your phone.

Minneapolis-Honeywell Regulator Co., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

LOFTUS PIT FURNACES

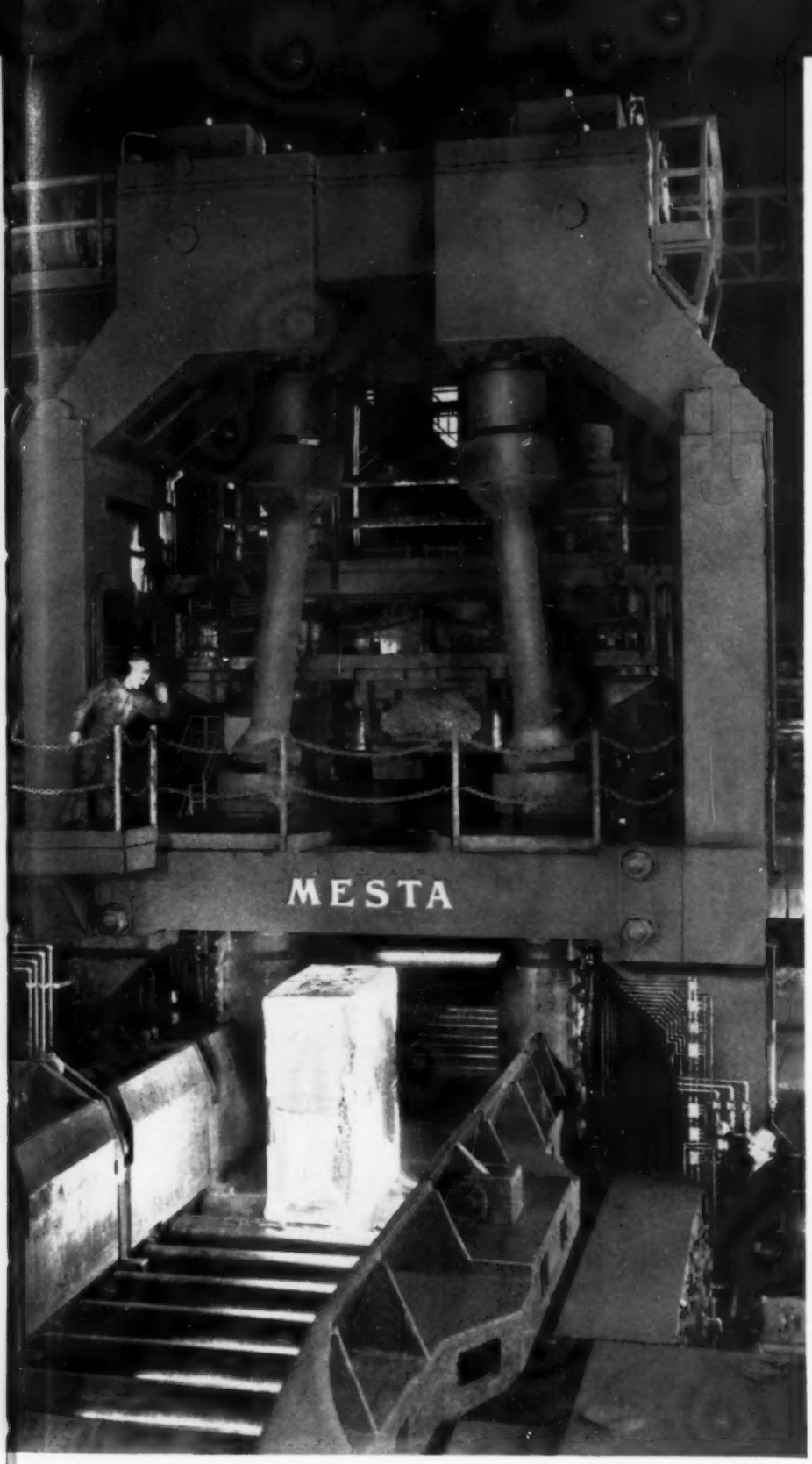
Insure top performance for each investment dollar, with the following distinct advantages:

- **Less investment with multi-purpose cover crane**
- **More production with heat acceleration**
- **More economy with integrated recuperation**
- **More uniform soak with flame tempering**
- **More setting capacity with top firing**
- **More flexibility with any fuel combination**
- **Less maintenance with flush carriage rails**

We solicit an opportunity to discuss your requirements—without obligation.

From first heat to heat treat, look to . . . **LOFTUS**
Engineering Corporation
1 Gateway Center, Pittsburgh, Pa.
140 S. Dearborn St., Chicago, Ill.

57.16.4



Experienced engineering and development

KEY TO HIGHER TONNAGE

...with Westinghouse-equipped reversing mills

Knocking down an ingot on schedule places heavy demands on your primary reversing mill. Drives and auxiliary equipment take rough abuse. To give you an edge in meeting demands, Westinghouse drives are engineered from long experience. New advances in Westinghouse automatic controls and coordinated auxiliary equipment keep your mill on schedule.

MP-3051

YOU CAN BE SURE...IF IT'S Westinghouse

Dependability is tailor made

Experience tailors each drive

Today, reversing mill drive equipment takes heavier abuse than ever before. Growing operating and tonnage requirements can't be met by yesterday's set of standards. That's why experienced engineering at Westinghouse tailors each drive to the specific mill. In this way, you can be sure of top performance, maximum accessibility to all parts of the drive, and rugged construction quality for reliability today and long into the future.

The Westinghouse reversing mill drive, at right, is a good example. Main drive is a 12,000 hp., 40/80 rpm double-armature twin motor. Edger drive (top) is a 4,000 hp., 60/150 rpm double-armature motor. Time-saving accessibility is provided by: 1) large walk-in endbells, 2) extra space for brush accessibility, both radially and axially, and 3) absence of baffle restrictions between the commutator area or the stator or rotor windings.

Heavy-duty thrust bearings are located at the mill end of the main drive pedestal bearings to permit easy, routine inspections. Removable end-case permits complete inspection and maintenance without disturbing either journal bearing or bearing cap.

Rugged construction of the Westinghouse reversing mill drive incorporates heavy-duty bedplates supported on concrete foundations. Pedestal cap bolts and base bolts extend deep into foundation concrete. Mill-end bearings are supported by massive pedestals using foundation keys. Each armature coil is rigidly and individually braced, front and rear. Armature coil cross connections are securly encased in a steel box at the rear of the rotor and flexibly connected to armature coils.

Oscillotrol (R) thrust oil-damper system effectively damps out rotor oscillations caused by pulses from mill-spindle coupling action on two-drive motors.

MP-3051

YOU CAN BE SURE...IF IT'S Westinghouse

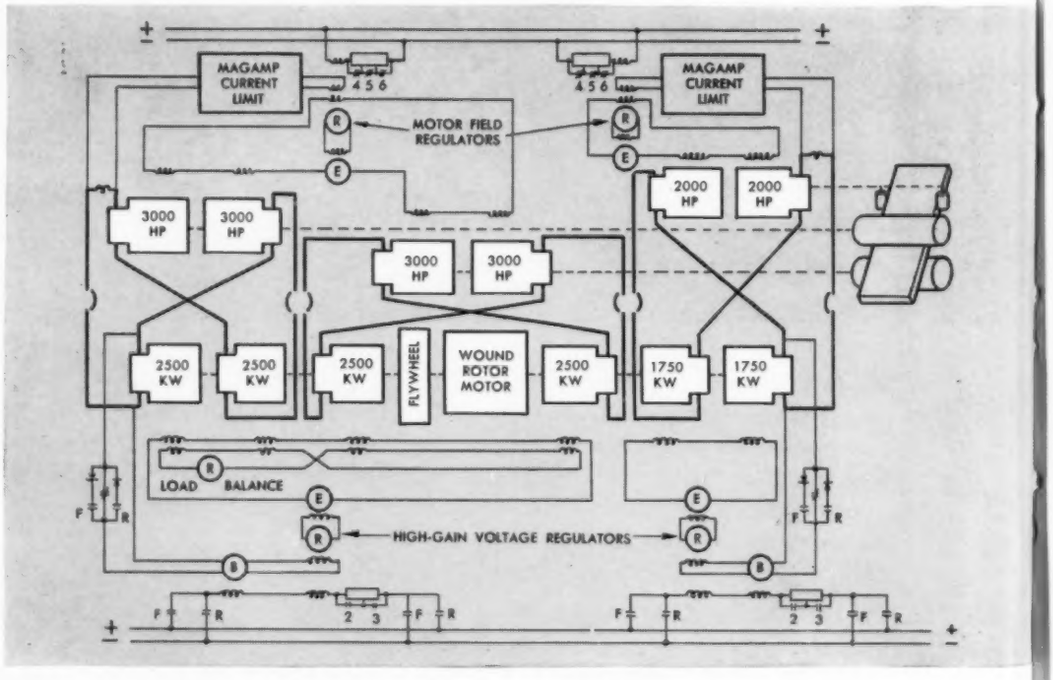
SYSTEM FEATURES

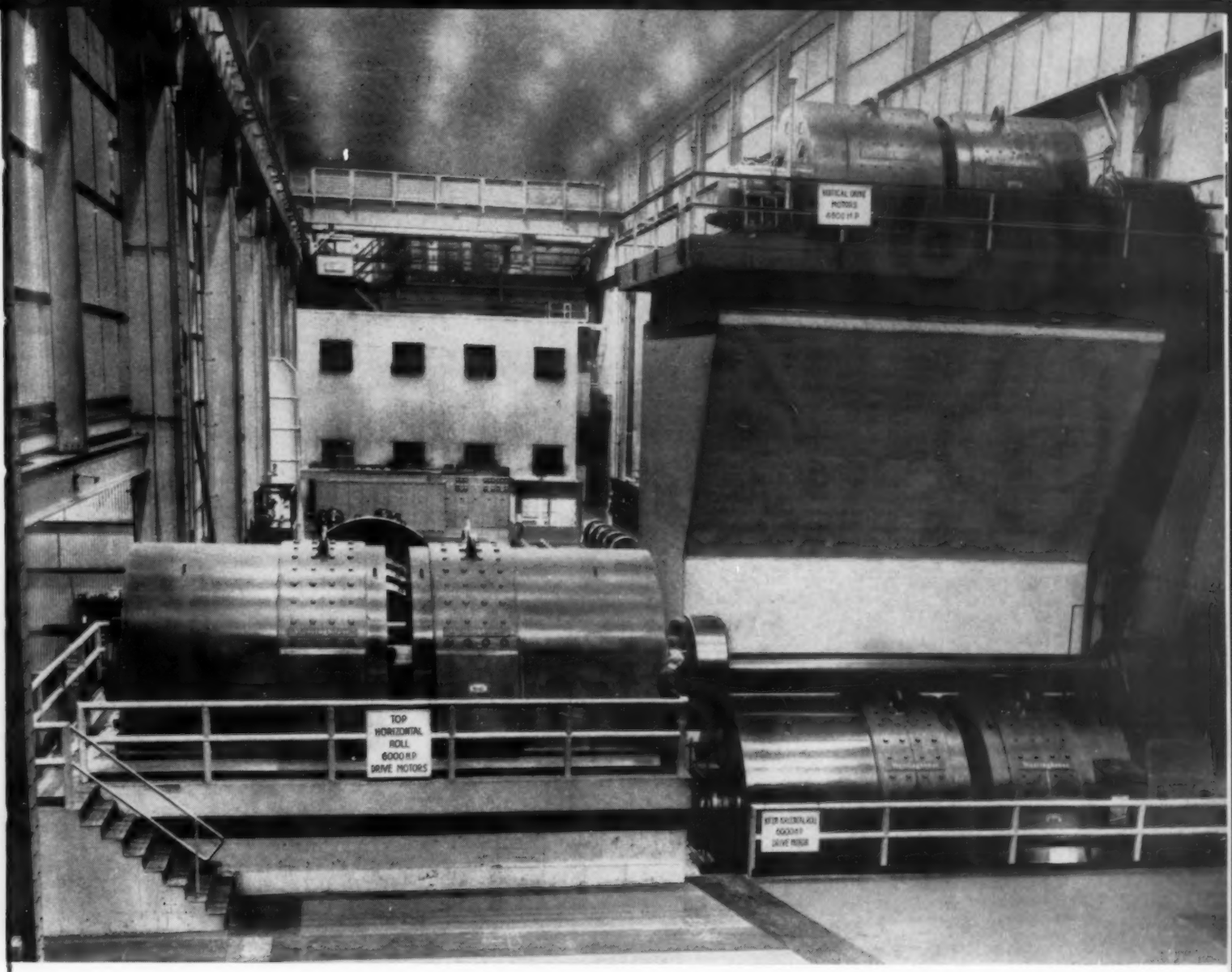
Sandwich series loops are used for each of the pairs of double-armature twin-drive motors and for the double-armature edger motor to minimize the number of circuit breakers and load balance equipment. A load balance regulator excites auxiliary fields on the 2500 kw generators to balance the twin-drive motor loads.

High-gain voltage regulators excite generators to give fast changes in response to the operator's controls.

Motor field regulators excite motors to give changes in speed by motor-field control.

MAGAMP (R) (magnetic amplifier) current-limit regulator builds up motor field strength to increase the torque per ampere for loads approaching 200%.





Typical reversing mill drive using 12,000 hp, 40/80 rpm double-armature twin motor. Edger drive (top) is 4,000 hp, 60/150 rpm double-armature motor.

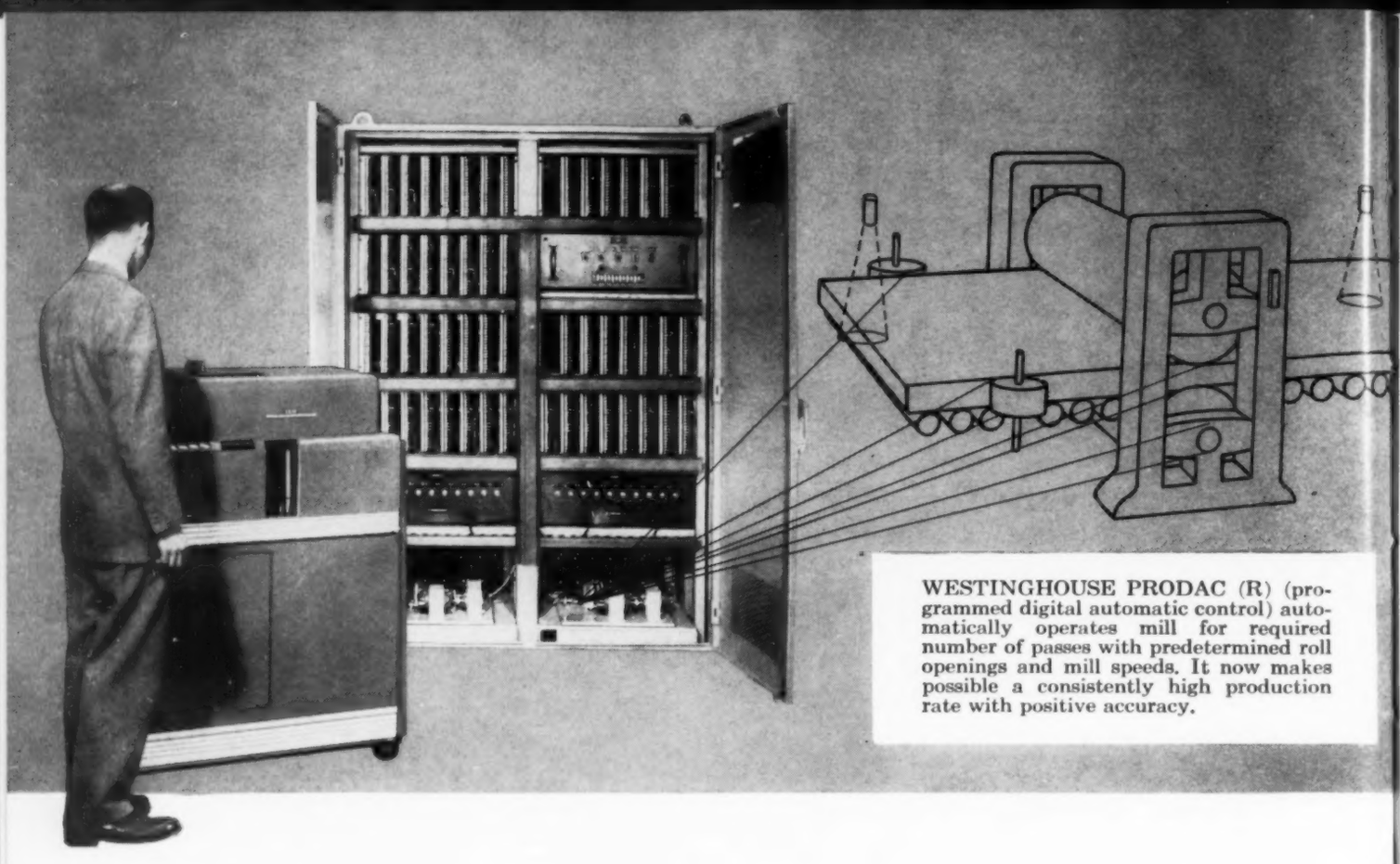
WESTINGHOUSE EQUIPMENT SERVES THESE USERS

YEAR	CUSTOMER	LOCATION	MILL	HP	RPM
1951	U. S. Steel Corporation	Fairless Hills, Pa.	40″ Blooming Mill	8000*	65/130
1951	☆Sheffield Steel Division	Kansas City, Mo.	32″ Blooming Mill	4000	60/150
1951	Laclede Steel Company	Alton, Illinois	35″ Blooming Mill	5000	60/150
1951	Dow Chemical Company	Madison, Illinois	84″ Reversing Mill	6000	55/156
1951	U. S. Steel Corporation	Morrisville, Pa.	Universal Slabbing Mill	12000*†	40/80
1951	°Great Lakes Steel Corporation	Detroit, Michigan	Universal Slabbing Mill	12000*†	40/80
1953	Reynolds Metals Company	McCook, Illinois	144″ Taper Mill	3000	125/250
1954	Inland Steel Company	Indiana Harbor, Ill.	Wide Flange Beam Mill	7000†	80/160
1955	Aluminum Company of Amer.	Davenport, Iowa	160″ Slabbing Mill	7000*	30/60
1955	Empressa Nacional Siderurgica	Spain	132″ Plate Mill	7000*	40/80
1955	Jones & Laughlin Steel Corp.	Cleveland, Ohio	Slabbing Mill	10000*	40/100
1955	Kaiser Al. & Chem. Corp.	Ravenswood, W. Va.	168″ Slabbing Mill	10000*†	30/60
1955	Kaiser Al. & Chem. Corp.	Ravenswood, W. Va.	110″ Slabbing Mill	6000	30/60
1955	Republic Steel Corp.	Cleveland, Ohio	Universal Slabbing Mill	12000*	40/80
1955	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	Reversing Rougher	6000*	40/100
1955	Jones & Laughlin Steel Corp.	Cleveland, Ohio	Reversing Rougher	8000*	40/80
1955	Crucible Steel Co. of Amer.	Midland, Pa.	Roughing Mill	3500	50/150
1955	Armco Steel Corporation	Butler, Pa.	Reversing Rougher	7000	40/100
1956	U. S. Steel Corporation	South Chicago, Illinois	Universal Slabbing Mill	12000*†	40/80
1956	U. S. Steel Corporation	Gary, Indiana	Universal Slabbing Mill	12000*†	40/80
1956	Altos Hornos	Mexico	Blooming Mill	6000*	40/80
1956	Large Eastern Steel Company		Blooming Mill	3000	60/150
1956	Reynolds Metals Company	Listerhill, Alabama	170″ Slabbing Mill	7000*	30/60
1956	Tata Iron & Steel	India	Reversing Rougher	3500*	60/150
1956	Kaiser Steel Company	Fontana, California	90″ Slabbing Mill	10000*	40/100
1956	Olin Mathieson Chem. Corp.	Omal, Ohio	96″ Slabbing Mill	5000	35/70
1956	Empire Steel Corporation	Mansfield, Ohio	Reversing Rougher	5000	50/120

☆Armco Steel Corp. °Division of National Steel Corp. *Twin Drive †Double Armature

MP-3051

Auxiliary equipment takes over more responsibility



WESTINGHOUSE PRODAC (R) (programmed digital automatic control) automatically operates mill for required number of passes with predetermined roll openings and mill speeds. It now makes possible a consistently high production rate with positive accuracy.

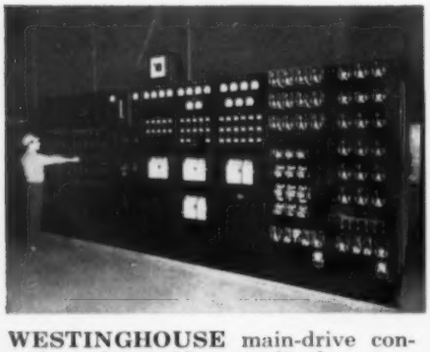
Reversing mills are more precise, automatic with Westinghouse auxiliaries

Continued research and development by Westinghouse helps to make your operations more precise and automatic. A recent example is PRODAC control. It makes possible the first completely automatic mill with card-programmed rolling information.

Unmatched Westinghouse engineering for high-tonnage reversing mill operation is at your service . . . from planning to design, installation and start-up. A skilled Westinghouse team will accept unit responsibility and work with you and your consulting engineers.

Contact your Westinghouse sales office for further details . . . Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pa.

MP-3051

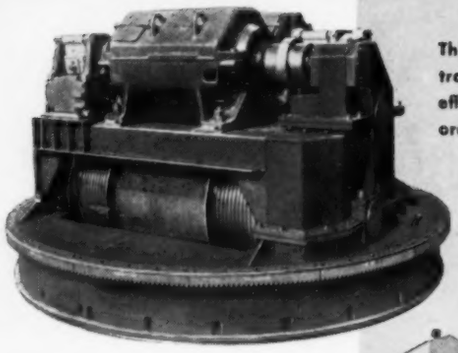


WESTINGHOUSE main-drive control panels provide centralized start-up switches for fans and motor-generator sets, and metering for power and regulating circuits.

WESTINGHOUSE variable voltage control for all auxiliaries minimizes handling time. Transfer switches and emergency bus arrangement afford relief in case of generator failure.

MCT600 INDIVIDUAL TABLE ROLL MOTOR, silicone insulated; drives mill tables directly; in ratings at 230 volts; frame sizes from 604 to 618; 3.75 hp to 50 hp, 157 rpm to 85 rpm.

YOU CAN BE SURE...IF IT'S Westinghouse



This turntable, mounted on the man trolley, is a vital component for efficient unloading operation of this ore bridge.

Ore Handling Brings to mind *Heyl & Patterson*

H & P BRIDGES HAVE THESE RECOGNIZED FEATURES:

- Wide flange beam construction to reduce dirt pockets.
- Adjustable voltage control for smooth trolley operation, for increased hoisting speed, for reduction of trolley weight, for drastically lowered power consumption.
- H & P special turntable for unloading bridges.
- Aluminum contact conductors.
- Fabreeka mountings for improving performance and lowering maintenance.
- Worm gear driven trucks—fully equalized.
- H & P automatic hydraulic rail clamps for bridge safety.
- H & P automatic hydraulic buffers for trolley safety.

Since 1905, Heyl & Patterson has built more than 100 Ore and Coal Bridges with most of them still in daily service.

Timely evidence of our continued leadership is that we have just completed one ore bridge and have three more ore bridges under construction.

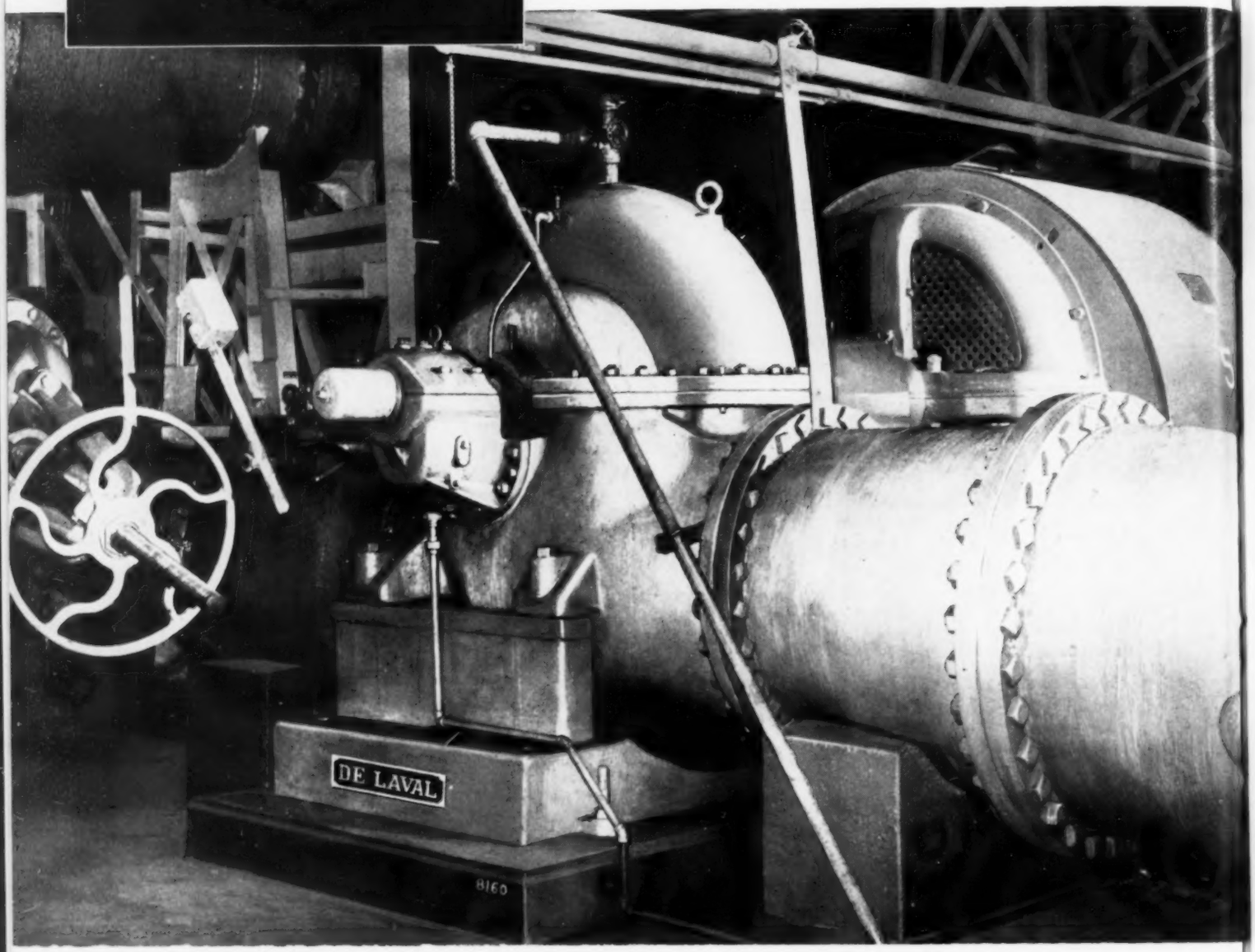
- **One 12 gross ton stocking and reclaiming bridge for an important West Virginia steel plant (the fourth H & P bridge for this customer).**
- **One 15 gross ton boat unloading, stocking and reclaiming bridge for a prominent Michigan steel company receiving ore by lake carriers.**
- **One 15 gross ton stocking and reclaiming bridge for a large Pennsylvania steel plant. It joins another H & P ore bridge operating since 1953.**
- **One 20 gross ton boat unloading, stocking and reclaiming bridge for a leading Canadian steel plant on the Great Lakes.**

Heyl & Patterson
INC.
53 FORT PITT BLVD. • PITTSBURGH 22, PA.

When Experience Counts . . .
Count On Heyl & Patterson!

DE LAVAL
CENTRIFUGAL PUMPS

in service since 1911 at Inland Steel Co.



De Laval Centrifugal Pumps have a record of dependability at the Inland Steel Co., which goes back forty-five years. In that time, De Laval has supplied this major producer with pumps for practically every steel mill service—*more than 75 units in all.* The photograph shows one of the largest De Laval pumps on the line at the East Chicago, Indiana plant of Inland Steel. The unit delivers 20,000 gpm at 120 ft head.

De Laval Centrifugal Pumps are available for a wide range of applications in all types of metal-working plants. Types L, M and P single stage double suction pumps can handle capacities from 1,000 to 20,000 gpm and heads to 350 feet. Larger De Laval units of any capacity to meet any requirement for steel mill service are available.

Send for Bulletin 1004 giving performance and application data.

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY
870 Nottingham Way, Trenton 2, New Jersey

DL 388

How about treating your family to a better chance against cancer?

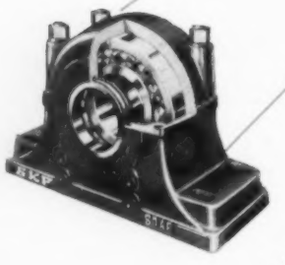
You give your family the best of everything . . . all-day outings in the car, maybe a movie after, and then a soda to top it all off. There's really nothing you wouldn't do to make your family happy.

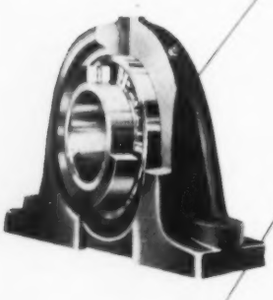
And if you could help make them safe . . . safe against cancer, you'd do that too, wouldn't you? And fast. Well, you *can* help. The American Cancer Society needs your dollars right now. It needs them for research, which is making important gains against the killer. For education, which gives everyone life-saving facts about cancer. For service, which aids and comforts the stricken.

Don't skip the treats that make life pleasant for the family. But don't skip the chance to strike back at a disease that threatens them. Match the cost of that next outing with a check to the American Cancer Society. That's the most worth-while treat you could give! Send your check to "Cancer" in care of your local Post Office today.

AMERICAN CANCER SOCIETY

Only Ten hands





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USE THE ENGINEERING MART

Equipment News

(*Continued from page 225*)

The switch mechanism of the standard duty selector switch is contained in the wrap-around cover. This switch possesses all the advantages of the push buttons described above. An unusual feature is that all of the new selector switches can be easily changed from a two position to a three position switch—or vice versa—in a matter of seconds. This is done by simply loosening two screws, rotating a metal plate through 90 deg, and tightening the screws again. A strip of seven name plates is furnished with each switch to meet any designation required. In effect, one of the new standard duty selector switches takes the place of seven separate switches, thus reducing the number of switches that must be carried in stock to take care of all requirements.

All Bulletin 800 push button and selector switch contacts are of double break, silver alloy construction and need no service attention. The a-c contact ratings are 3 amp, 110 v; 2 amp, 220 v; and 1 amp, 440–550 v. The d-c ratings are 1 amp, 115 v; 0.5 amp, 230 v; and 0.2 amp, 550 v.

CLAY GUNS

▲Two new clay guns for use with electric furnaces have been developed by William M. Bailey Co. The guns, which are modifications of the large Bailey clay guns for blast furnaces, have capacities of three and six cu ft—each having ample power for slugging tapping holes.

The three cu ft-capacity gun is pedestal-mounted in front of individual furnaces. It is operated by three separate electric motors which move the gun in three directions—horizontally, forward and downward into the tapping hole.

The six cu ft-capacity gun was developed to service a series of electric furnaces. The gun is positioned in front of the furnace by movement along overhead rails. It enters the tapping hole by a forward and downward movement.

PUMPS

▲Ingersoll-Rand Co., offers a line of circulating and coolant pumps for sidewall or immersion mounting. They have no stuffing boxes, no pump bearings and no couplings. Their long shaft construction permits high liquid levels. Vent holes provided high in the supporting head protect the motor should the liquid level in the column rise to excessive heights. The balanced impeller is mounted directly on an oversize motor shaft and thus eliminates the need for a coupling. The rigidness of the shaft eliminates the need for bearings. These features, the company claims, have reduced maintenance to a negligible amount.

Sidewall mounted units are built in $\frac{3}{4}$-in., 1-in. and $1\frac{1}{2}$-in. sizes with single discharge, also $\frac{3}{4}$-in. and $1\frac{1}{4}$-in. dual discharge units. Horsepower range is $\frac{1}{4}$ to 5 with deliveries to 180 gpm at heads to 90 ft.

The immersion types are built in $\frac{3}{4}$-in. to 3-in. discharge sizes with a horsepower range from $\frac{1}{4}$ to 10 and deliveries to 500 gpm at heads to 160 ft.

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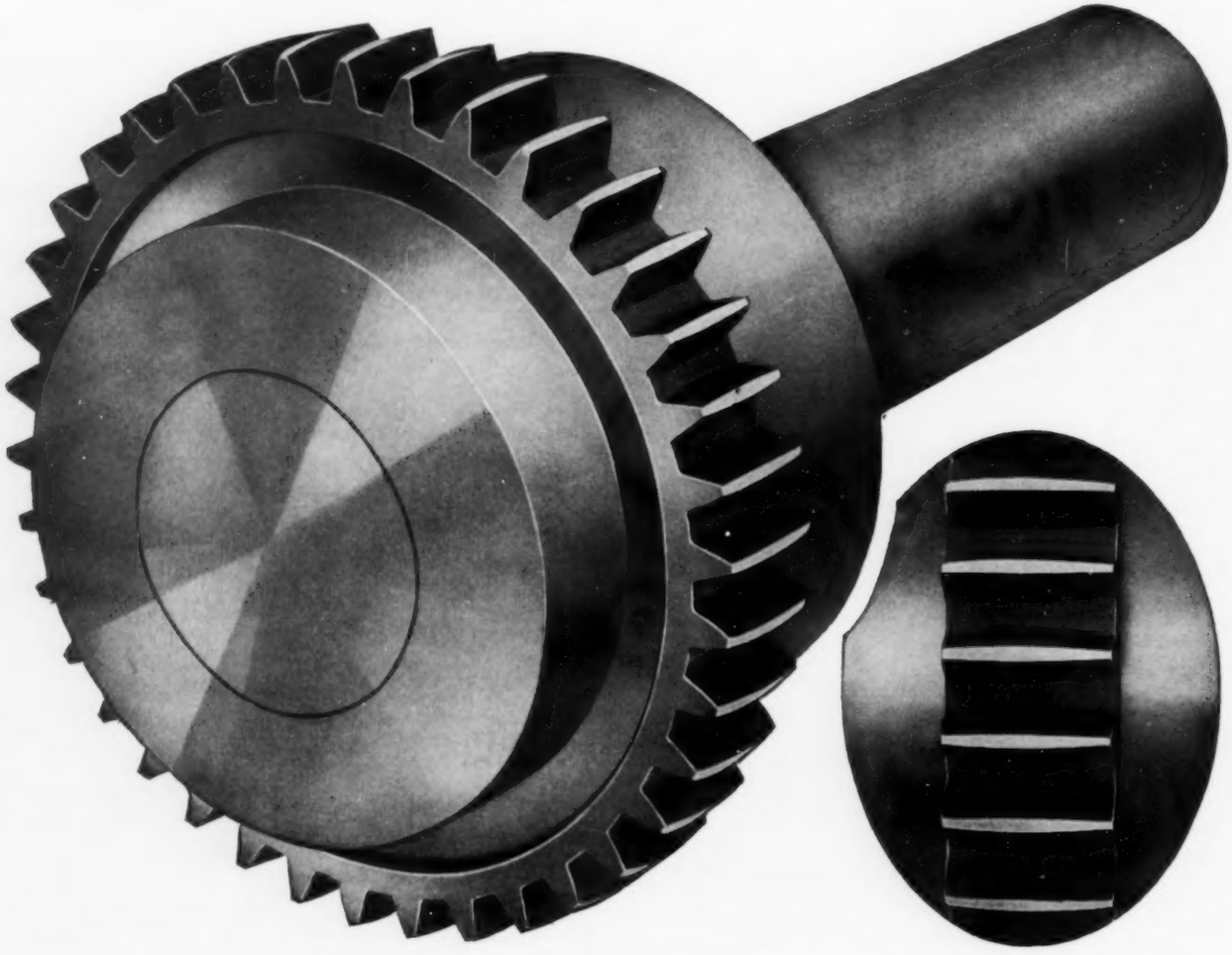

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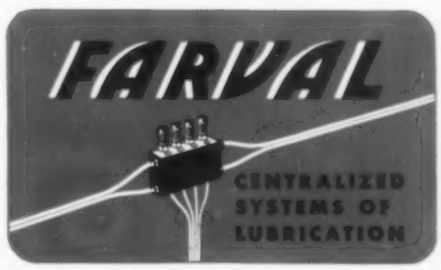

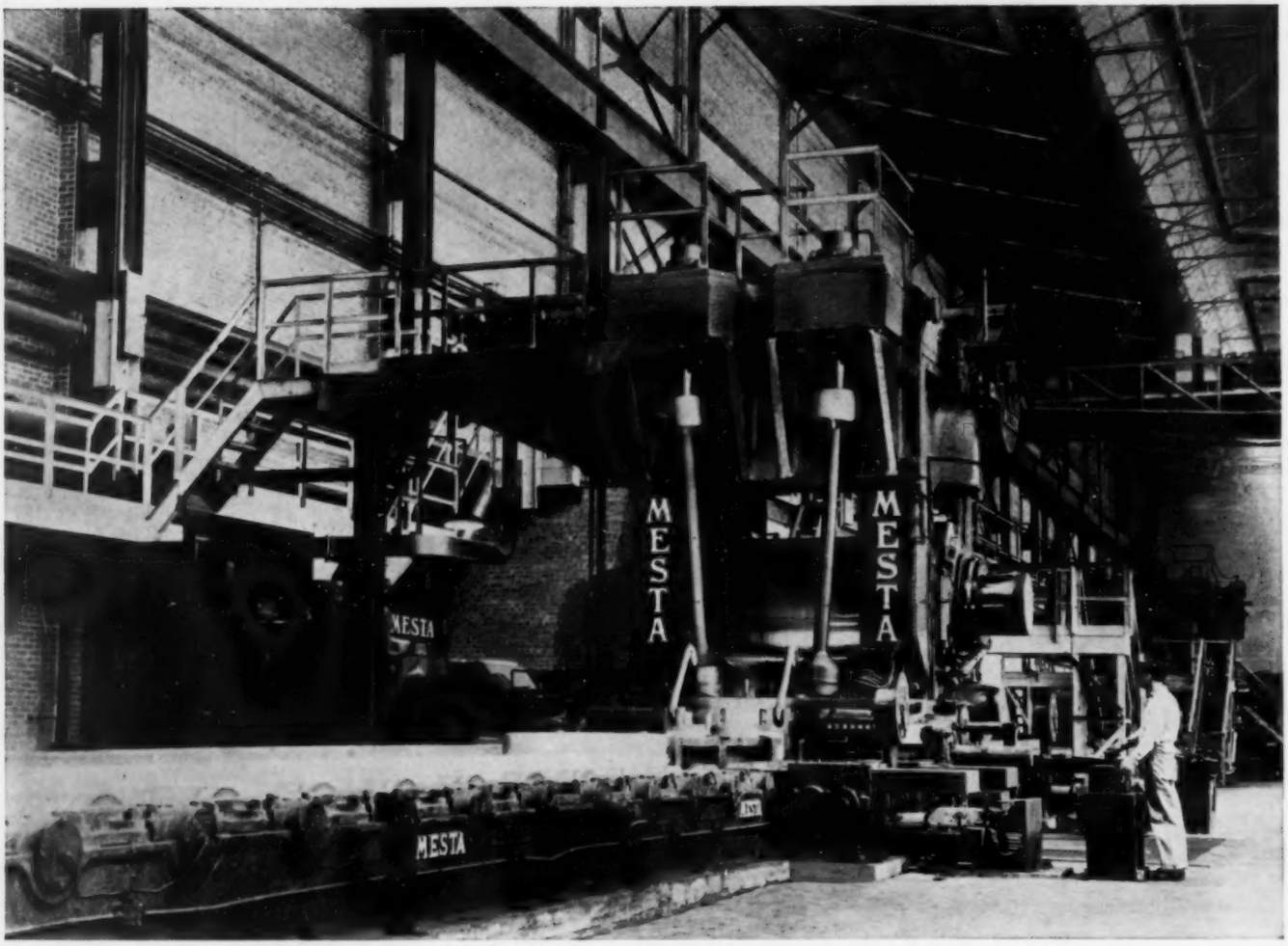

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